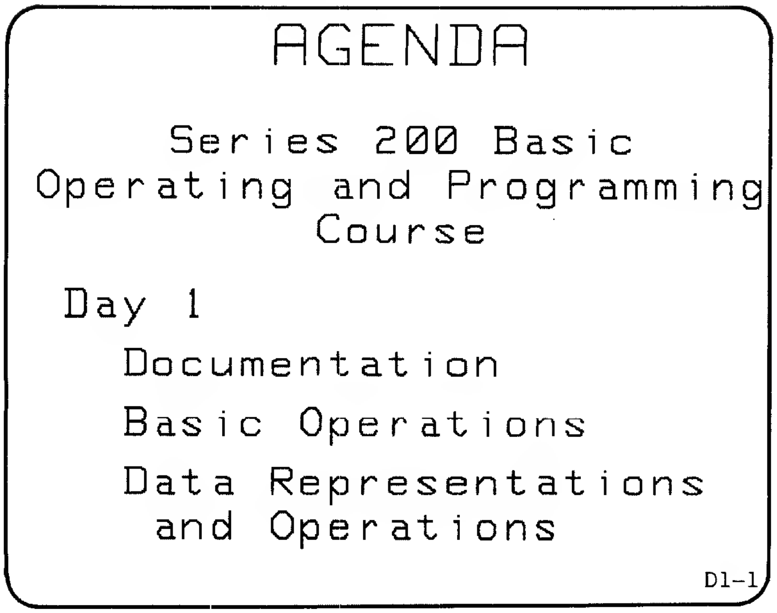
HP Computer Systems – *Student*

9826/36
Basic Language

Operating & Programming Course

HEWLETT PACKARD



AGENDA

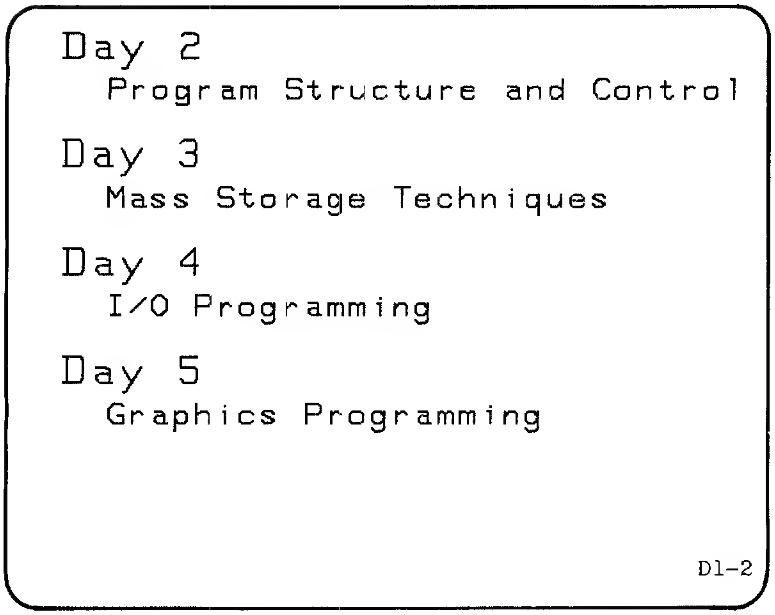
Series 200 Basic
Operating and Programming
Course

Day 1

- Documentation
- Basic Operations
- Data Representations and Operations

D1-1

NOTES



Day 2
Program Structure and Control

Day 3
Mass Storage Techniques

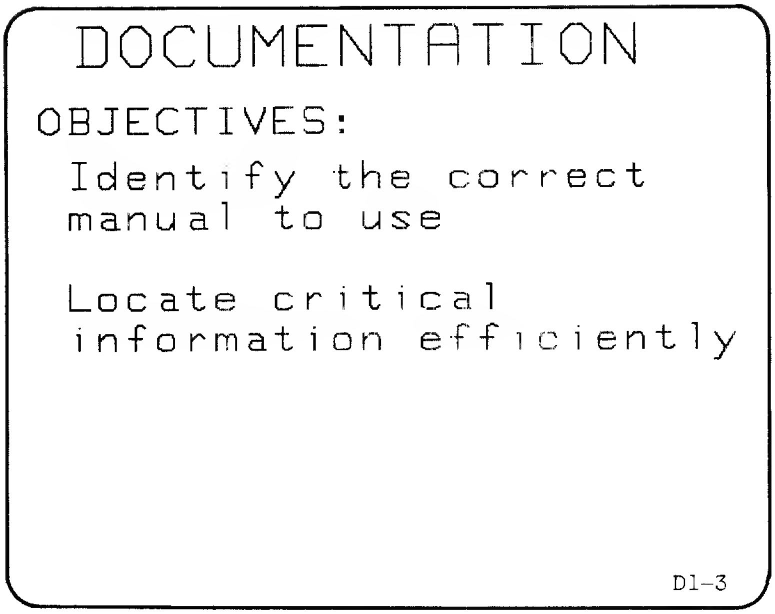
Day 4
I/O Programming

Day 5
Graphics Programming

D1-2

NOTES

NOTES



DOCUMENTATION

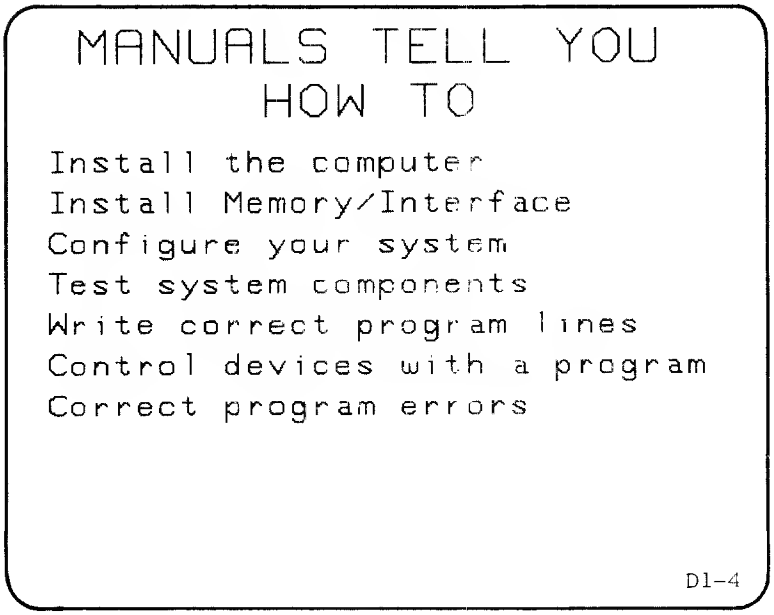
OBJECTIVES:

Identify the correct manual to use

Locate critical information efficiently

D1-3

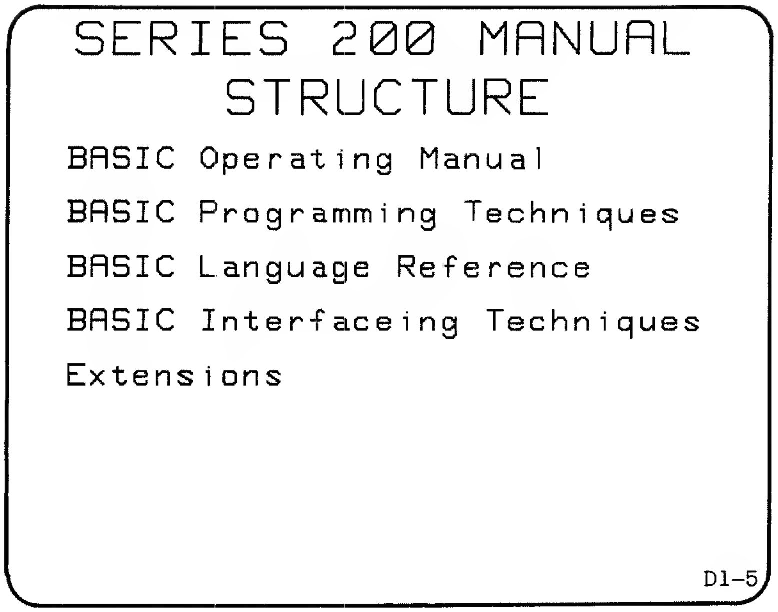
NOTES



MANUALS TELL YOU HOW TO

Install the computer
Install Memory/Interface
Configure your system
Test system components
Write correct program lines
Control devices with a program
Correct program errors

D1-4



SERIES 200 MANUAL STRUCTURE

BASIC Operating Manual

BASIC Programming Techniques

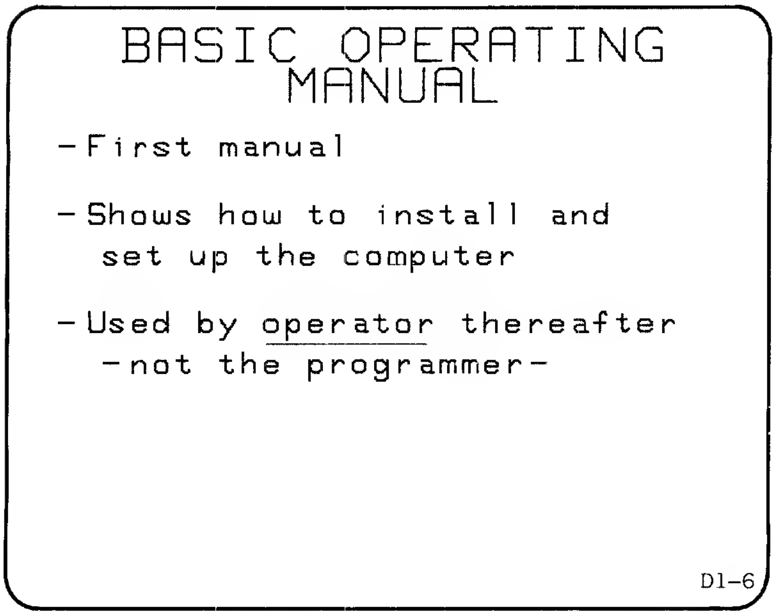
BASIC Language Reference

BASIC Interfaceing Techniques

Extensions

D1-5

NOTES



BASIC OPERATING MANUAL

- First manual

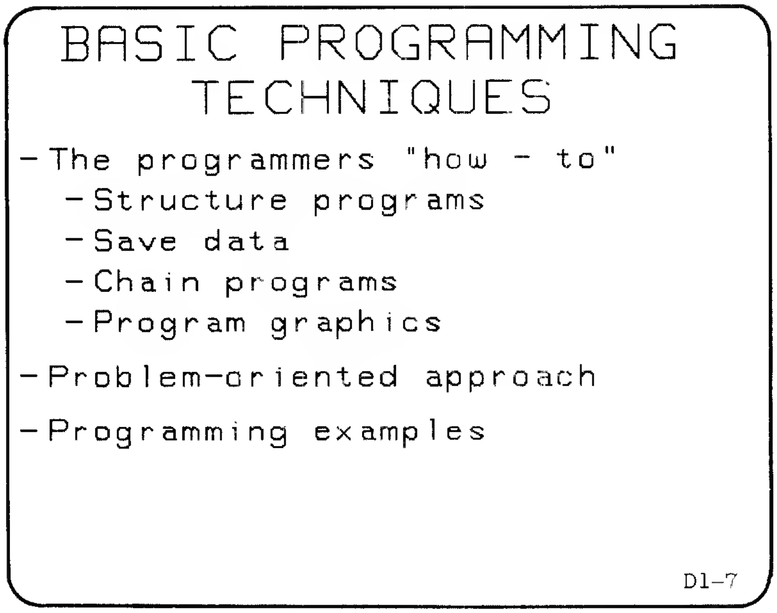
- Shows how to install and set up the computer

- Used by operator thereafter -not the programmer-

D1-6

NOTES

NOTES

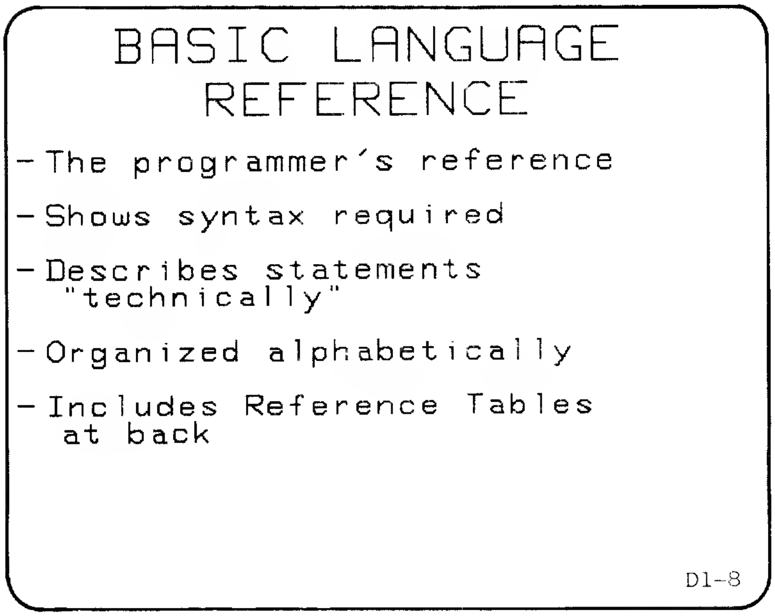


BASIC PROGRAMMING TECHNIQUES

- The programmers "how - to"
  - Structure programs
  - Save data
  - Chain programs
  - Program graphics
- Problem-oriented approach
- Programming examples

D1-7

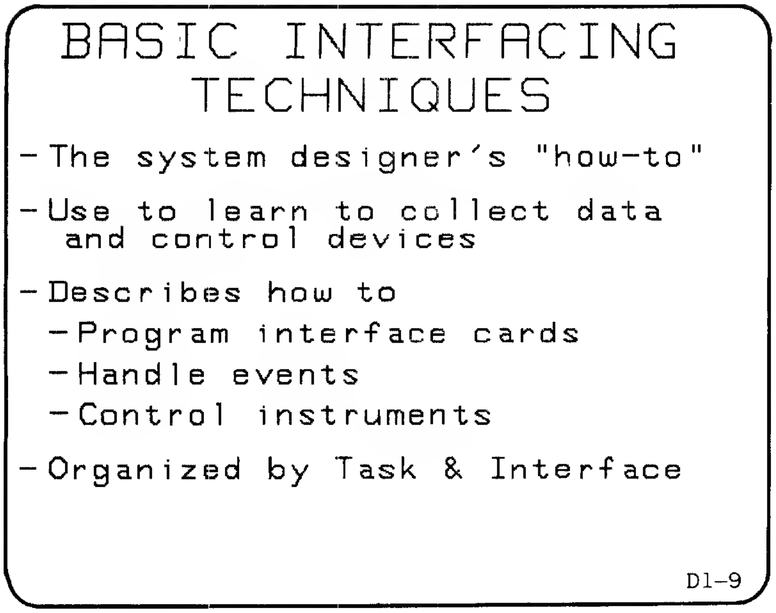
NOTES



BASIC LANGUAGE REFERENCE

- The programmer's reference
- Shows syntax required
- Describes statements "technically"
- Organized alphabetically
- Includes Reference Tables at back

D1-8

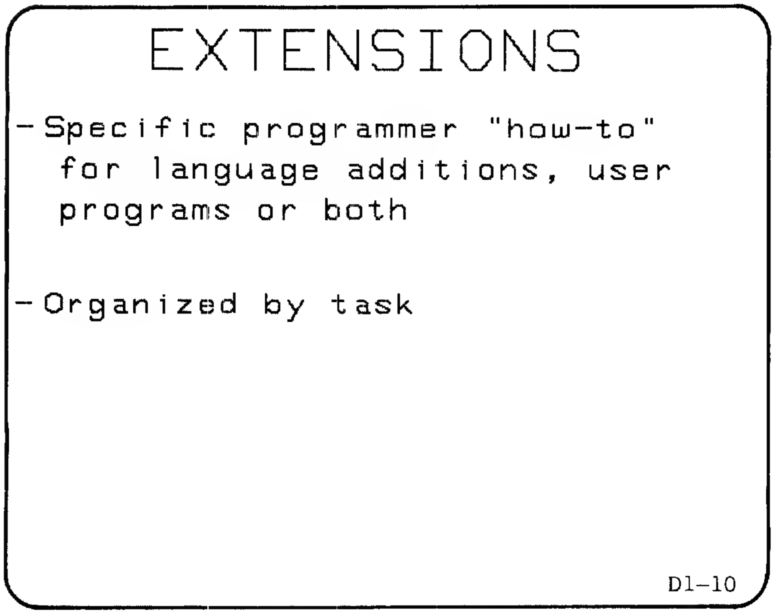


BASIC INTERFACING TECHNIQUES

- The system designer's "how-to"
- Use to learn to collect data and control devices
- Describes how to
  - Program interface cards
  - Handle events
  - Control instruments
- Organized by Task & Interface

D1-9

NOTES



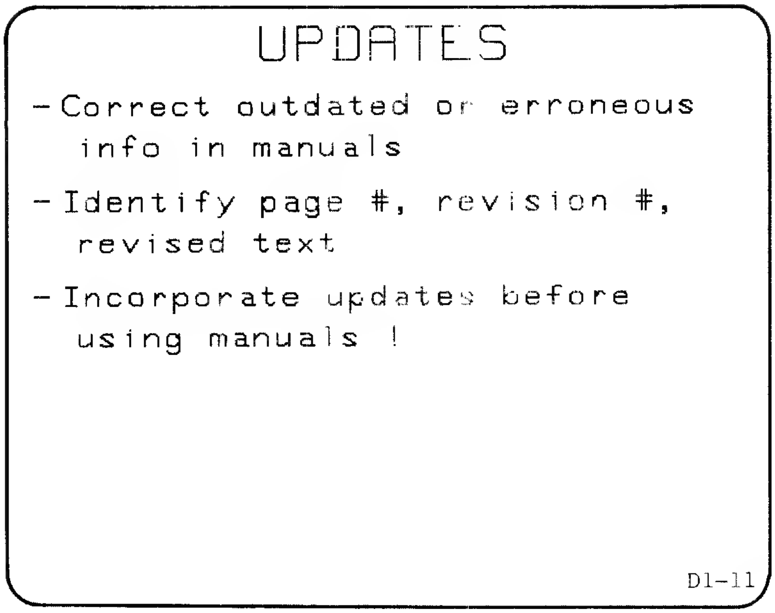
EXTENSIONS

- Specific programmer "how-to" for language additions, user programs or both
- Organized by task

D1-10

NOTES

NOTES

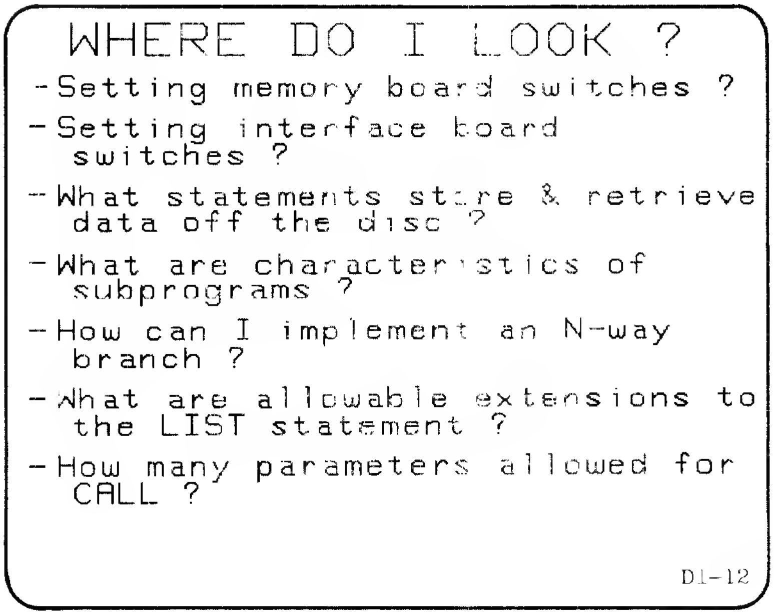


UPDATES

- Correct outdated or erroneous info in manuals
- Identify page #, revision #, revised text
- Incorporate updates before using manuals !

D1-11

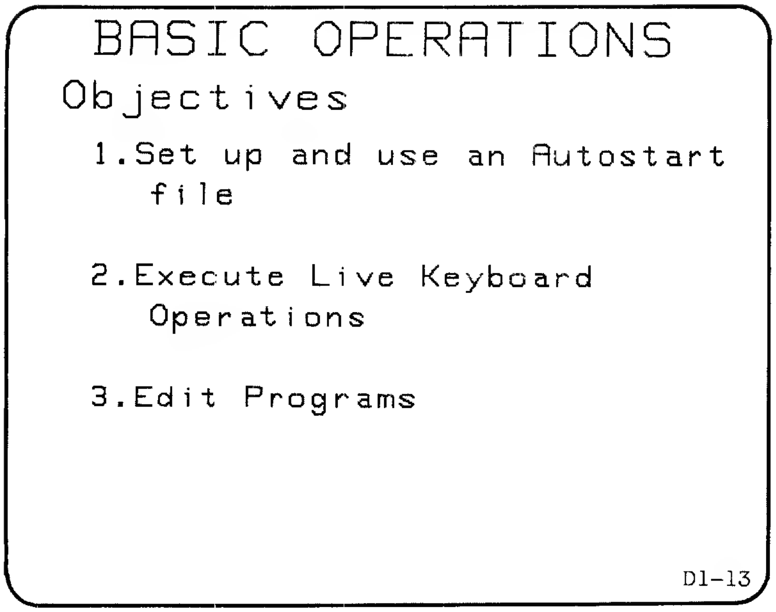
NOTES



WHERE DO I LOOK ?

- Setting memory board switches ?
- Setting interface board switches ?
- What statements store & retrieve data off the disc ?
- What are characteristics of subprograms ?
- How can I implement an N-way branch ?
- What are allowable extensions to the LIST statement ?
- How many parameters allowed for CALL ?

D1-12



BASIC OPERATIONS

Objectives

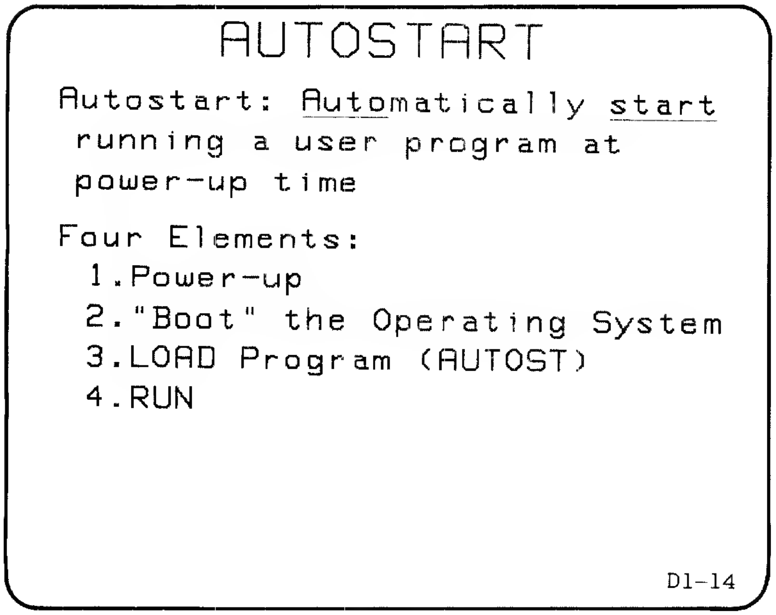
1. Set up and use an Autostart file

2. Execute Live Keyboard Operations

3. Edit Programs

D1-13

NOTES



AUTOSTART

Autostart: Automatically start running a user program at power-up time

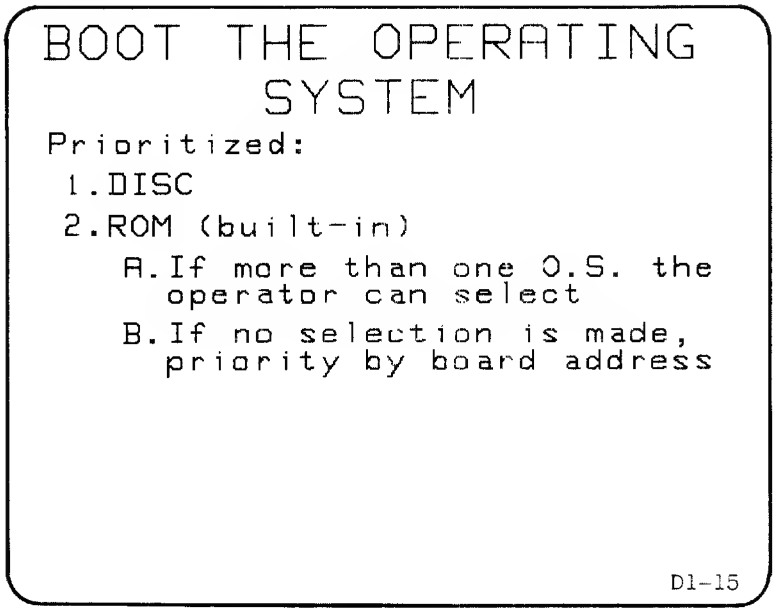
Four Elements:

1. Power-up
2. "Boot" the Operating System
3. LOAD Program (AUTOST)
4. RUN

D1-14

NOTES

NOTES



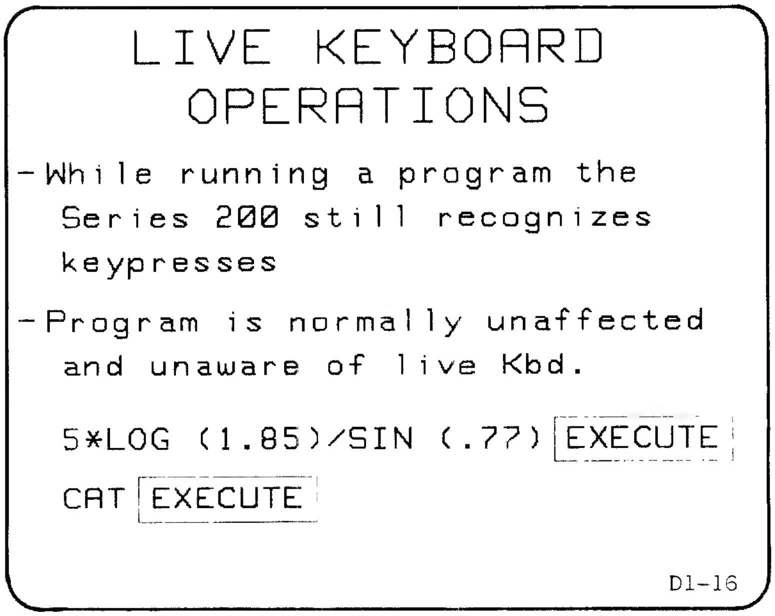
BOOT THE OPERATING SYSTEM

Prioritized:

1. DISC
2. ROM (built-in)
   A. If more than one O.S. the operator can select
   B. If no selection is made, priority by board address

D1-15

NOTES



LIVE KEYBOARD OPERATIONS

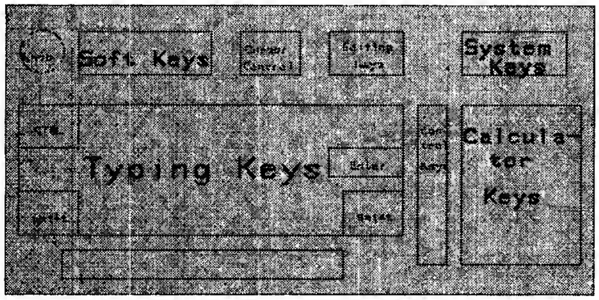
- While running a program the Series 200 still recognizes keypresses
- Program is normally unaffected and unaware of live Kbd.

5*LOG (1.85)/SIN (.77) EXECUTE

CAT EXECUTE

D1-16

KEYBOARD FUNCTIONAL AREAS



D1-17

NOTES

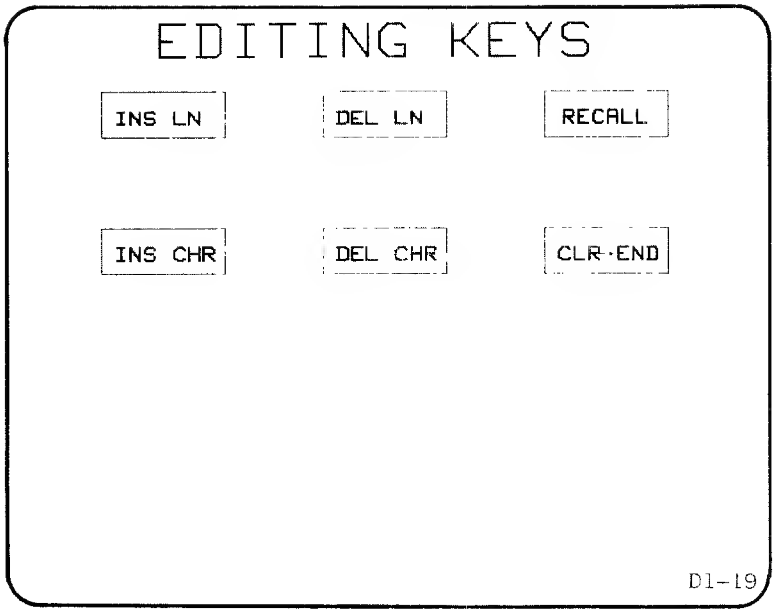
SYSTEM KEYS

DISPLAY FCTNS	DUMP ALPHA	DUMP GRAPHICS	ANY CHAR
EDIT	ALPHA	GRAPHICS	STEP
CLR SCR	SET TAB	CLR TAB	STOP
CLR LN	RESULT	PRT ALL	CLR I/O

D1-18

NOTES

NOTES



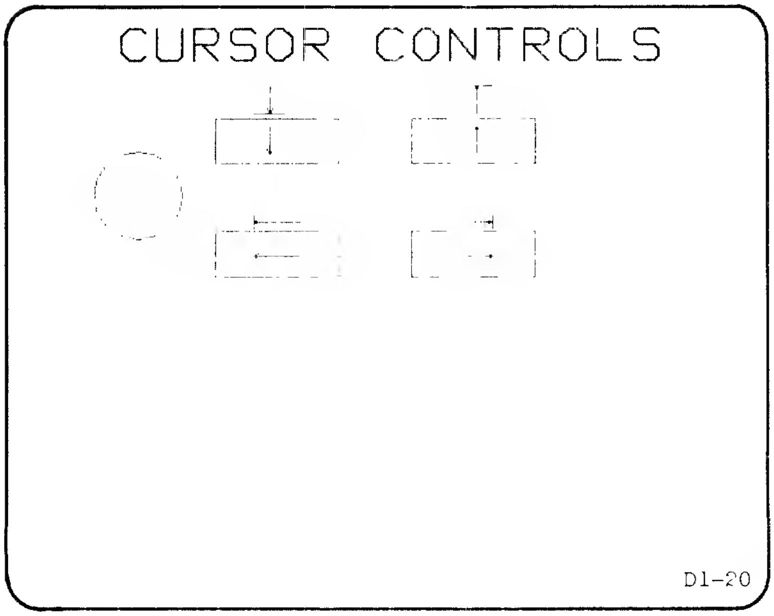
EDITING KEYS

INS LN DEL LN RECALL

INS CHR DEL CHR CLR·END

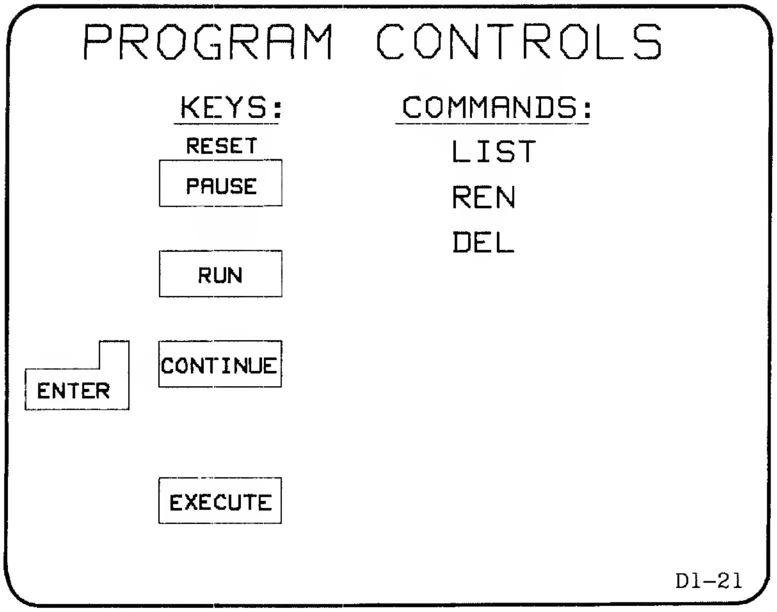
D1-19

NOTES



CURSOR CONTROLS

D1-20

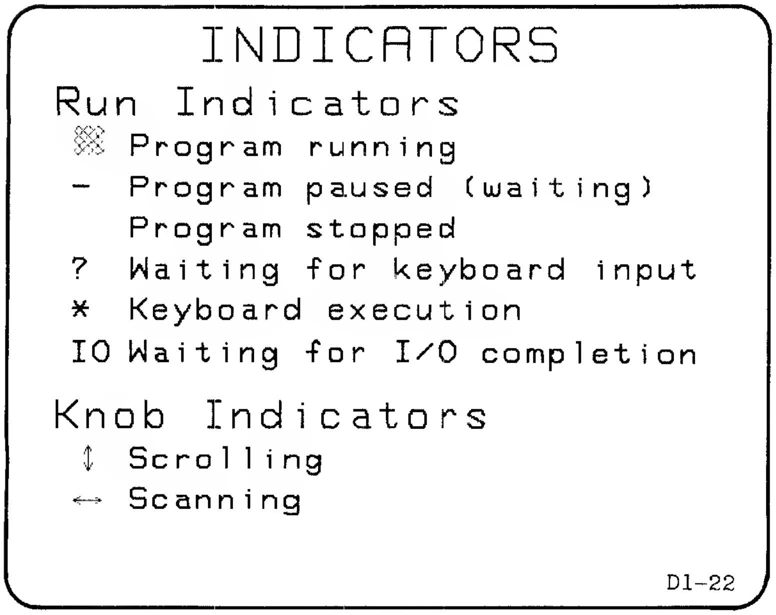


PROGRAM CONTROLS

KEYS:	COMMANDS:
RESET PAUSE	LIST
RUN	REN
ENTER CONTINUE	DEL
EXECUTE	

D1-21

NOTES



INDICATORS

Run Indicators

▨ Program running
- Program paused (waiting)
  Program stopped
? Waiting for keyboard input
* Keyboard execution
IO Waiting for I/O completion

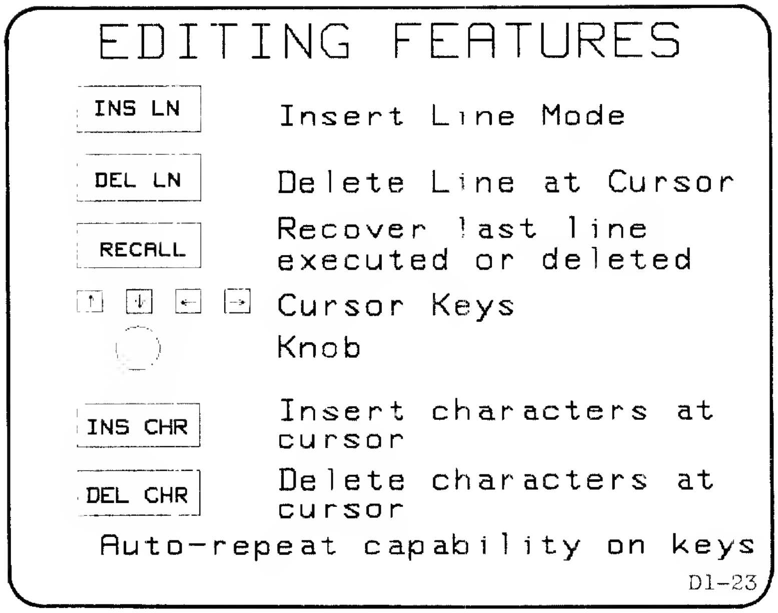
Knob Indicators

↕ Scrolling
↔ Scanning

D1-22

NOTES

NOTES



EDITING FEATURES

INS LN — Insert Line Mode

DEL LN — Delete Line at Cursor

RECALL — Recover last line executed or deleted

↑ ↓ ← → Cursor Keys

○ Knob

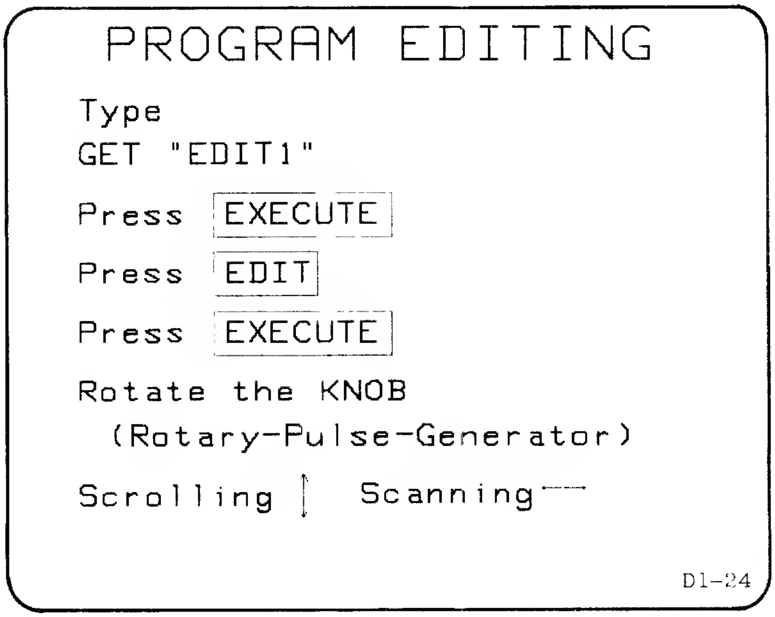
INS CHR — Insert characters at cursor

DEL CHR — Delete characters at cursor

Auto-repeat capability on keys

D1-23

NOTES



PROGRAM EDITING

Type

GET "EDIT1"

Press EXECUTE

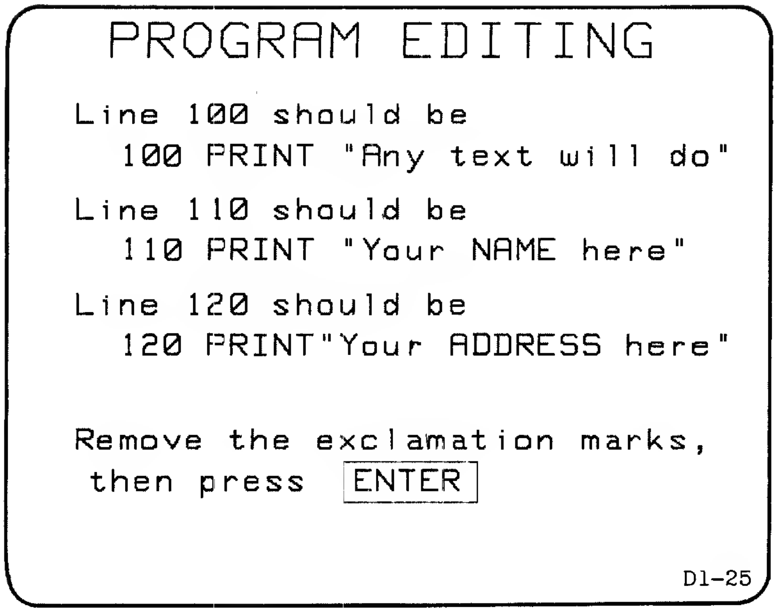
Press EDIT

Press EXECUTE

Rotate the KNOB
(Rotary-Pulse-Generator)

Scrolling ↕ Scanning ↔

D1-24



PROGRAM EDITING

Line 100 should be

```
  100 PRINT "Any text will do"
```

Line 110 should be

```
  110 PRINT "Your NAME here"
```

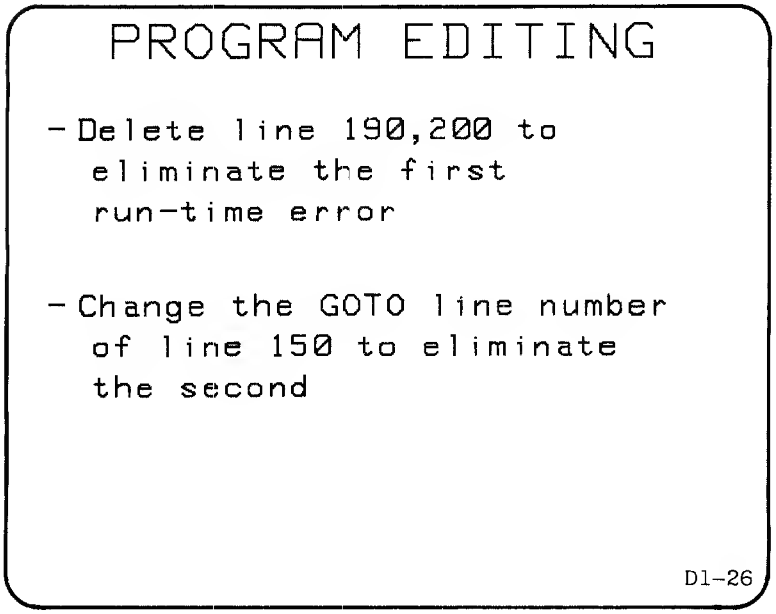
Line 120 should be

```
  120 PRINT"Your ADDRESS here"
```

Remove the exclamation marks,
then press ENTER

D1-25

NOTES



PROGRAM EDITING

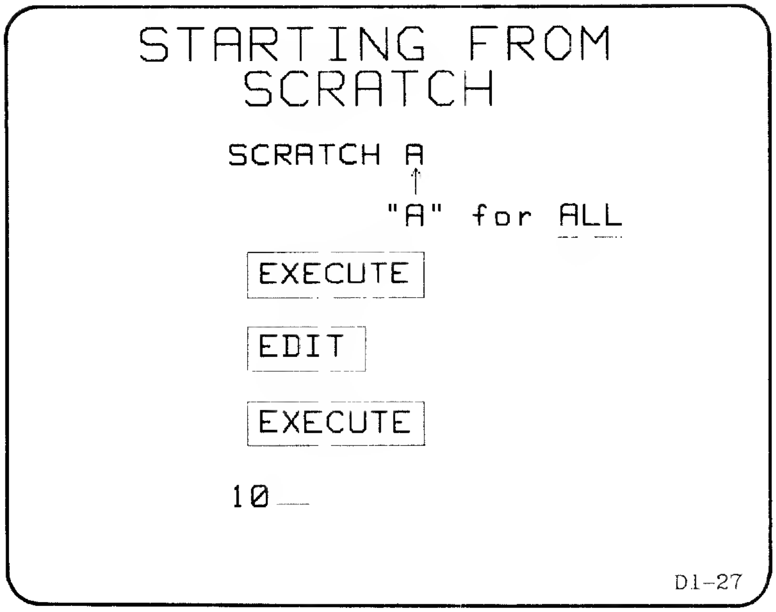
- Delete line 190,200 to eliminate the first run-time error

- Change the GOTO line number of line 150 to eliminate the second

D1-26

NOTES

NOTES



STARTING FROM SCRATCH

SCRATCH A

"A" for ALL

EXECUTE

EDIT

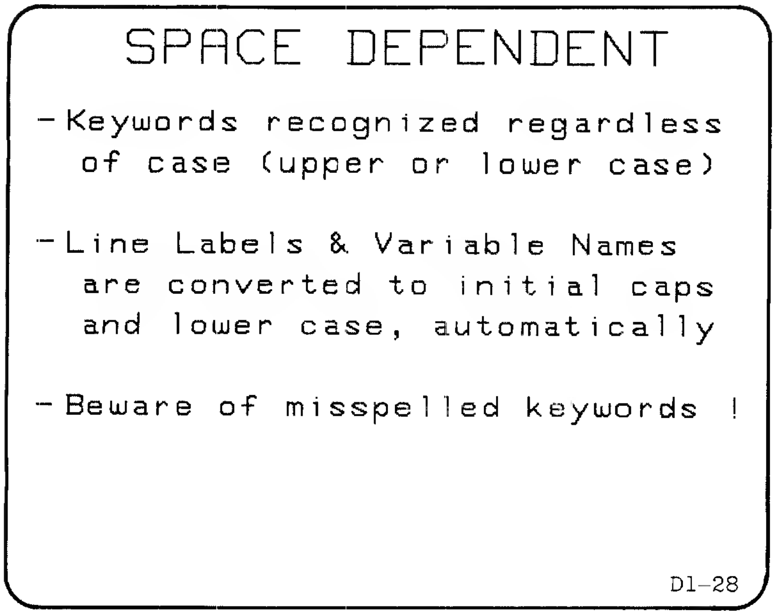
EXECUTE

10_

D1-27

```
10      REM     Computation of Depreciation
20      REM     Three computation methods
30      !
40      PRINT
50      PRINT
60      PRINT "Enter a 1 for Straight-Line method"
70      PRINT "Enter a 2 for Decling Balance method"
80      PRINT "Enter a 3 for Sum-of-Years method"
90      INPUT "Method?",I
100     INPUT "Enter the value",V
110     INPUT "Enter the number of years",N
120     PRINT
130     !
140     ON I GOTO 160,190,220
150     !
160     PRINT "Straight-line method"
170       GOTO 240
180       !
190     PRINT "Declining balance method"
200       GOTO 240
210       !
220     PRINT "Sum-of-years method"
230     !
240     LET J=0
250     LET D1=V/N
260     LET F1=V/(N*(N+1)/2)
270     PRINT "Year"," Depr"," Value"
280     LET J=J+1
290     ON I GOTO 320,400,510
300     !
310     !
```

```
320   REM Straight-line method
330   !
340   LET V=V-D1
350   PRINT J,D1,V
360   IF J<N THEN 280
370   STOP
380   !
390   !
400   REM Double declining balance method
410   !
420   LET D2=(2/N)*V
430   LET D2=DROUND(D2,6)
440   LET V=V-D2
450   LET V=DROUND(V,6)
460   PRINT J,D2,V
470   IF J<N THEN 280
480   STOP
490   !
500   !
510   REM Sum-of-year's digits method
520   !
530   LET F2=N-J+1
540   LET D3=F1*F2
550   LET D3=DROUND(D3,6)
560   LET V=V-D3
570   LET V=DROUND(V,6)
580   PRINT J,D3,V
590   IF J<N THEN 280
600   END
```



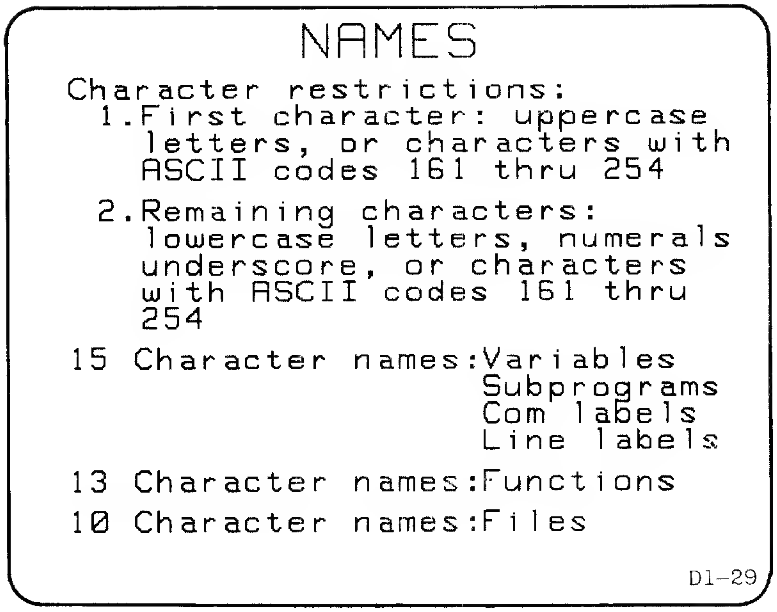
SPACE DEPENDENT

- Keywords recognized regardless of case (upper or lower case)
- Line Labels & Variable Names are converted to initial caps and lower case, automatically
- Beware of misspelled keywords !

D1-28

NOTES

NOTES



NAMES

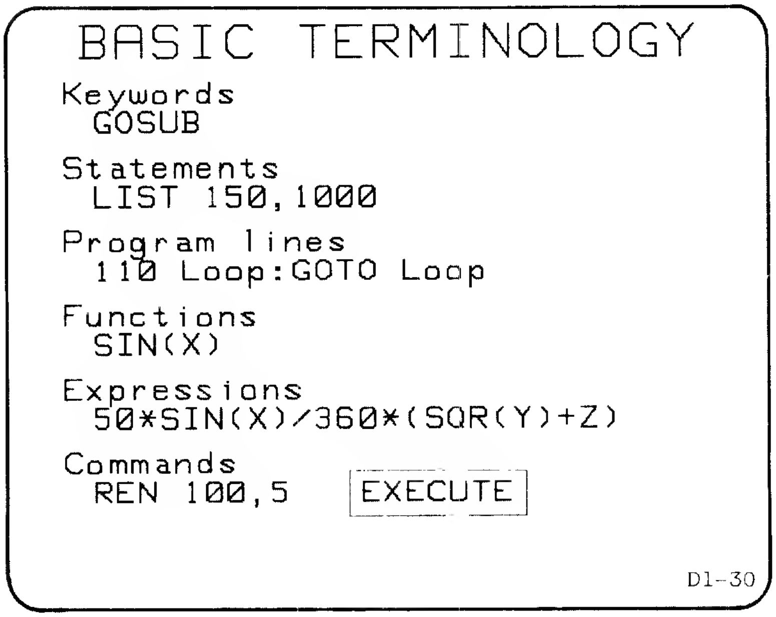
Character restrictions:

1. First character: uppercase letters, or characters with ASCII codes 161 thru 254
2. Remaining characters: lowercase letters, numerals underscore, or characters with ASCII codes 161 thru 254

```
15 Character names:Variables
                   Subprograms
                   Com labels
                   Line labels

13 Character names:Functions

10 Character names:Files
```

D1-29

NOTES



BASIC TERMINOLOGY

Keywords
GOSUB

Statements
LIST 150,1000

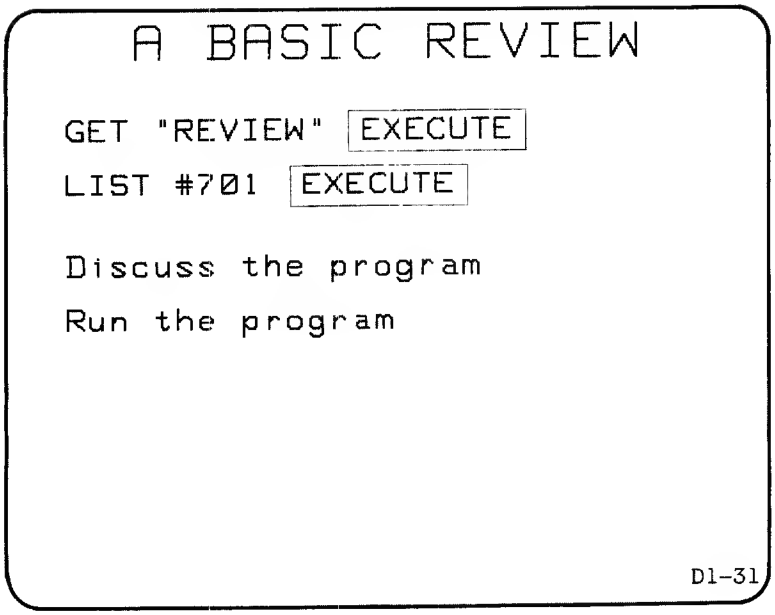
Program lines
110 Loop:GOTO Loop

Functions
SIN(X)

Expressions
50*SIN(X)/360*(SQR(Y)+Z)

Commands
REN 100,5 EXECUTE

D1-30



A BASIC REVIEW

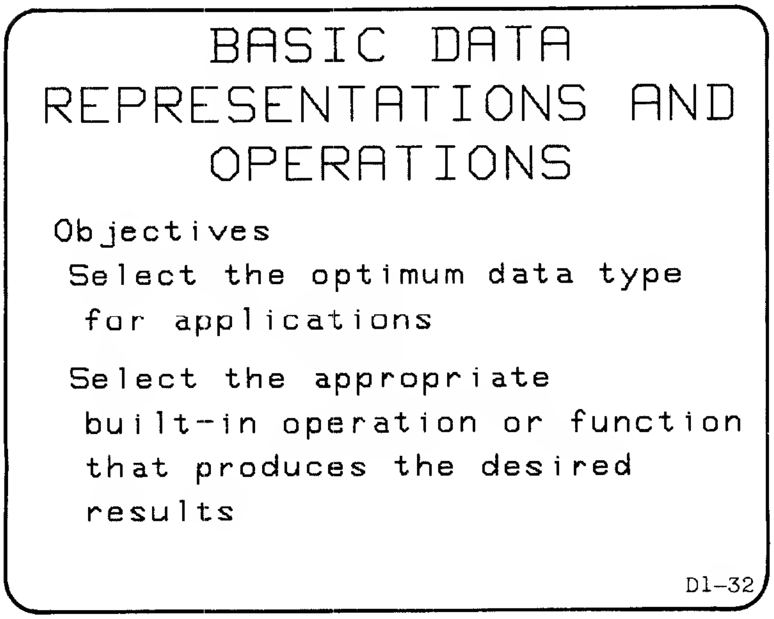
```
GET "REVIEW" EXECUTE
LIST #701 EXECUTE
```

Discuss the program

Run the program

D1-31

NOTES



BASIC DATA REPRESENTATIONS AND OPERATIONS

Objectives

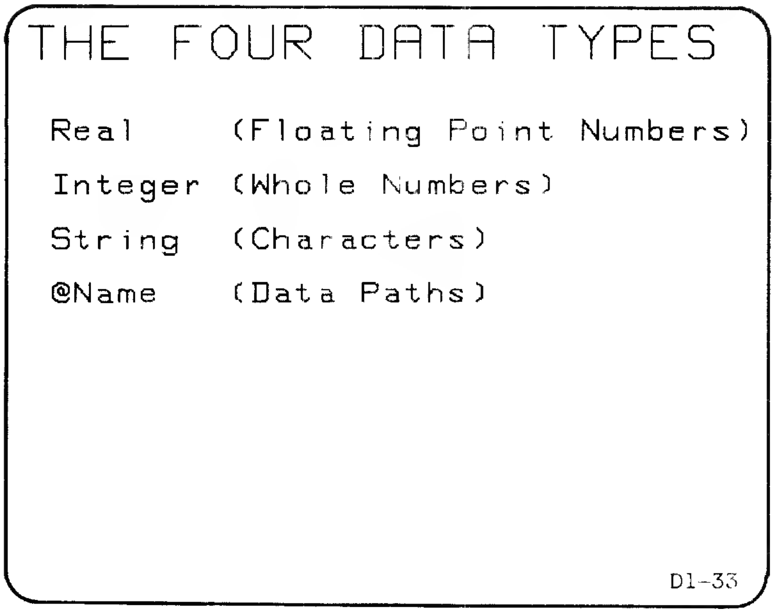
Select the optimum data type for applications

Select the appropriate built-in operation or function that produces the desired results

D1-32

NOTES

NOTES

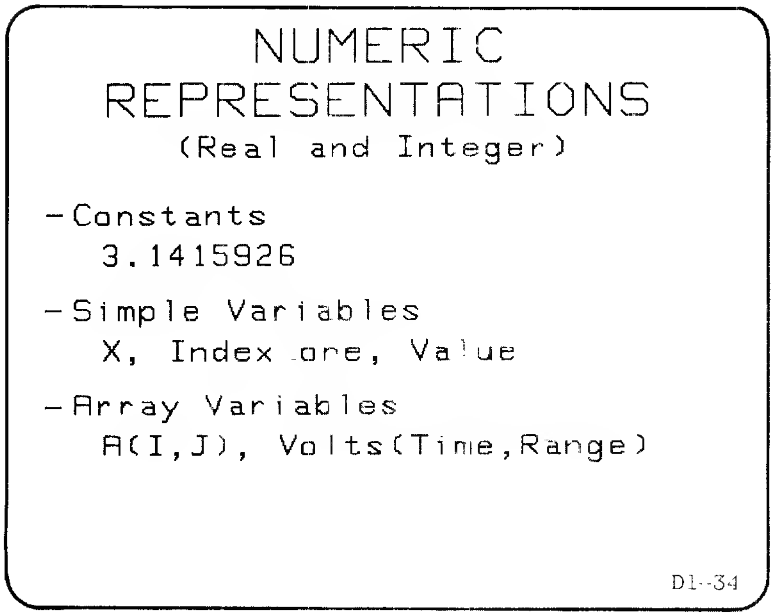


THE FOUR DATA TYPES

Real	(Floating Point Numbers)
Integer	(Whole Numbers)
String	(Characters)
@Name	(Data Paths)

D1-33

NOTES

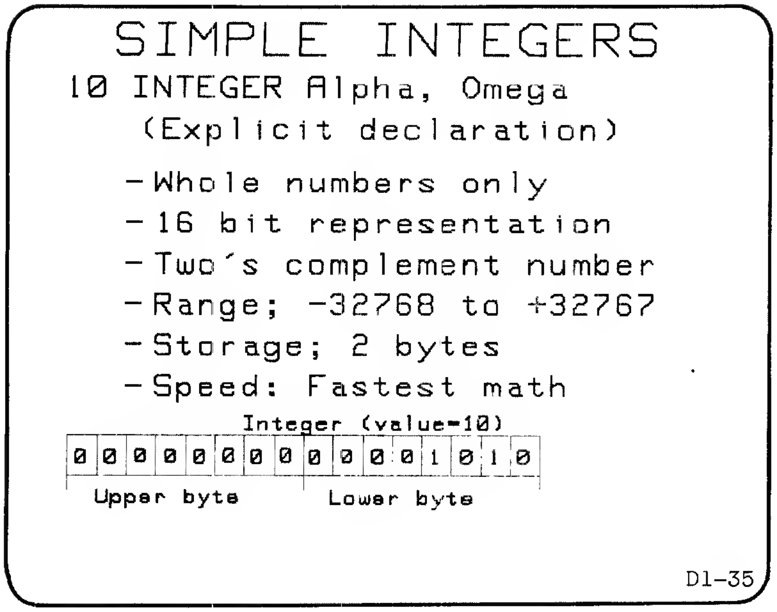


NUMERIC REPRESENTATIONS

(Real and Integer)

- Constants
  3.1415926
- Simple Variables
  X, Index_ore, Value
- Array Variables
  A(I,J), Volts(Time,Range)

D1-34



SIMPLE INTEGERS

10 INTEGER Alpha, Omega
(Explicit declaration)

- Whole numbers only
- 16 bit representation
- Two´s complement number
- Range; -32768 to +32767
- Storage; 2 bytes
- Speed: Fastest math

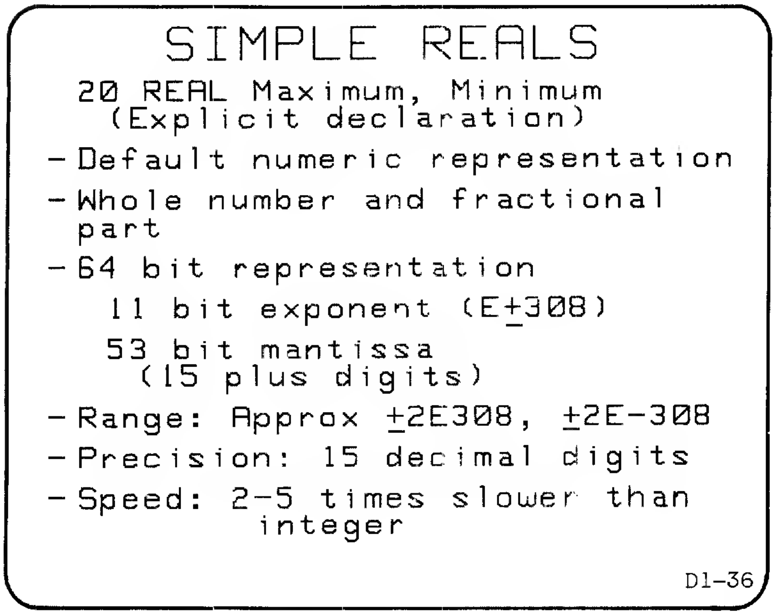
Integer (value=10)

0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

Upper byte   Lower byte

D1-35

NOTES



SIMPLE REALS

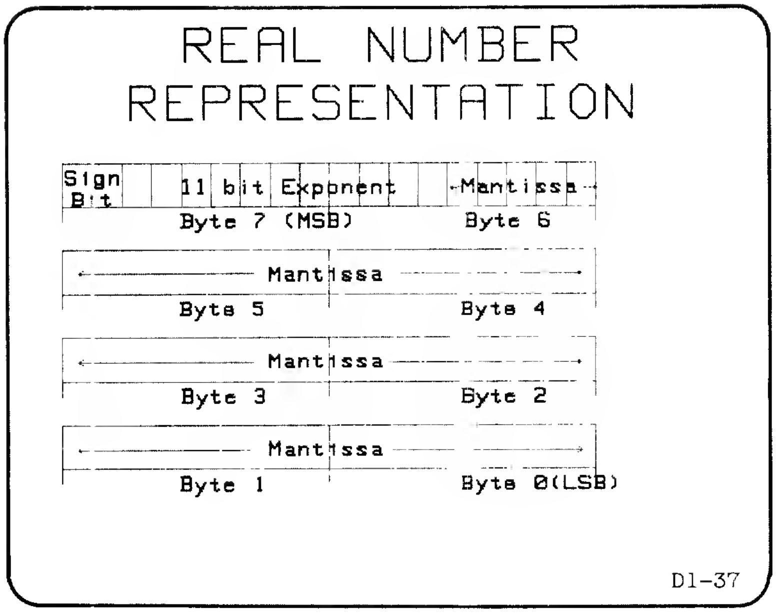
20 REAL Maximum, Minimum
(Explicit declaration)

- Default numeric representation
- Whole number and fractional part
- 64 bit representation
  11 bit exponent (E±308)
  53 bit mantissa
  (15 plus digits)
- Range: Approx ±2E308, ±2E-308
- Precision: 15 decimal digits
- Speed: 2-5 times slower than integer

D1-36

NOTES

NOTES

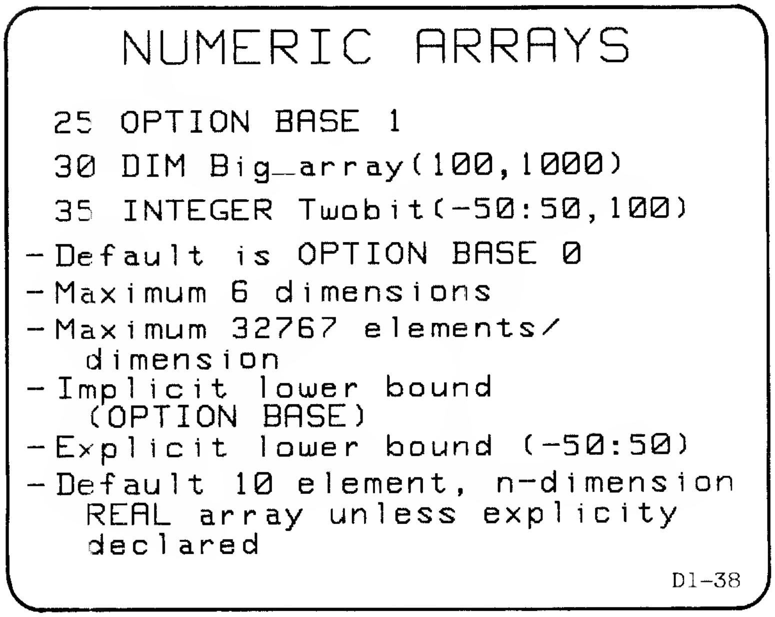


REAL NUMBER REPRESENTATION

Sign Bit 11 bit Exponent	Mantissa
Byte 7 (MSB)	Byte 6
Mantissa	
Byte 5	Byte 4
Mantissa	
Byte 3	Byte 2
Mantissa	
Byte 1	Byte 0(LSB)

D1-37

NOTES

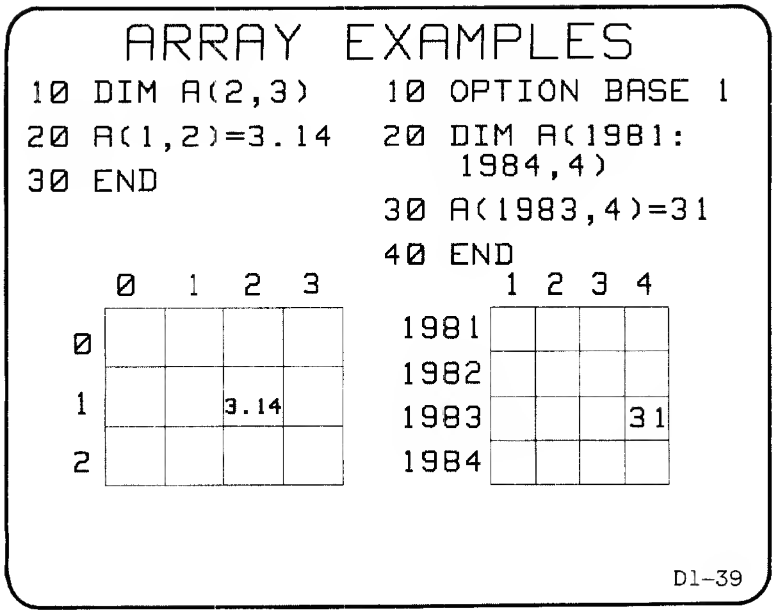


NUMERIC ARRAYS

```
25 OPTION BASE 1
30 DIM Big_array(100,1000)
35 INTEGER Twobit(-50:50,100)
```

- Default is OPTION BASE 0
- Maximum 6 dimensions
- Maximum 32767 elements/ dimension
- Implicit lower bound (OPTION BASE)
- Explicit lower bound (-50:50)
- Default 10 element, n-dimension REAL array unless explicity declared

D1-38



ARRAY EXAMPLES

```
10 DIM A(2,3)
20 A(1,2)=3.14
30 END
```

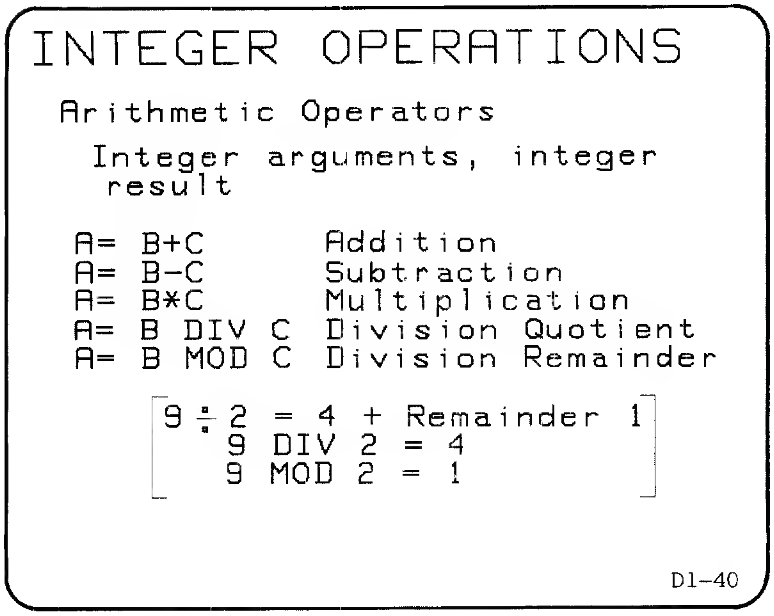
```
10 OPTION BASE 1
20 DIM A(1981:
    1984,4)
30 A(1983,4)=31
40 END
```

	0	1	2	3
0				
1			3.14	
2				

	1	2	3	4
1981				
1982				
1983				31
1984				

D1-39

NOTES



INTEGER OPERATIONS

Arithmetic Operators

Integer arguments, integer result

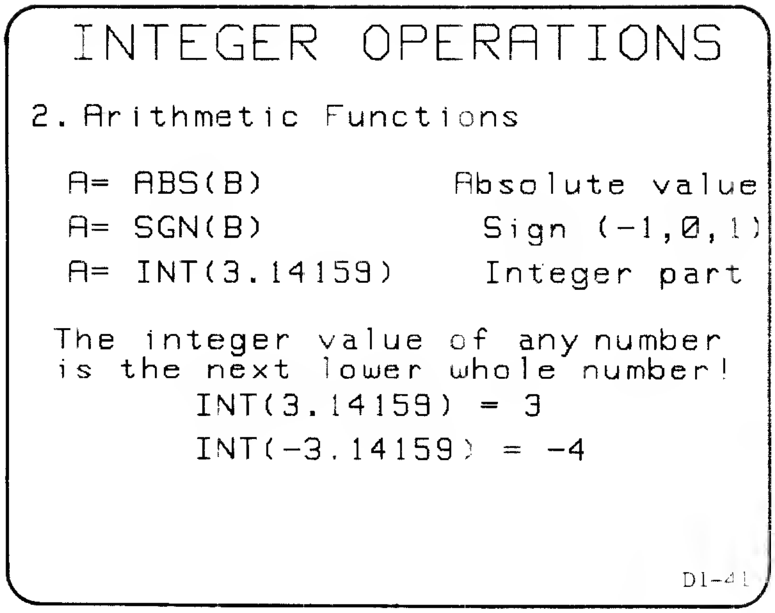
A= B+C	Addition
A= B-C	Subtraction
A= B*C	Multiplication
A= B DIV C	Division Quotient
A= B MOD C	Division Remainder

9 ÷ 2 = 4 + Remainder 1
9 DIV 2 = 4
9 MOD 2 = 1

D1-40

NOTES

NOTES



INTEGER OPERATIONS

2. Arithmetic Functions

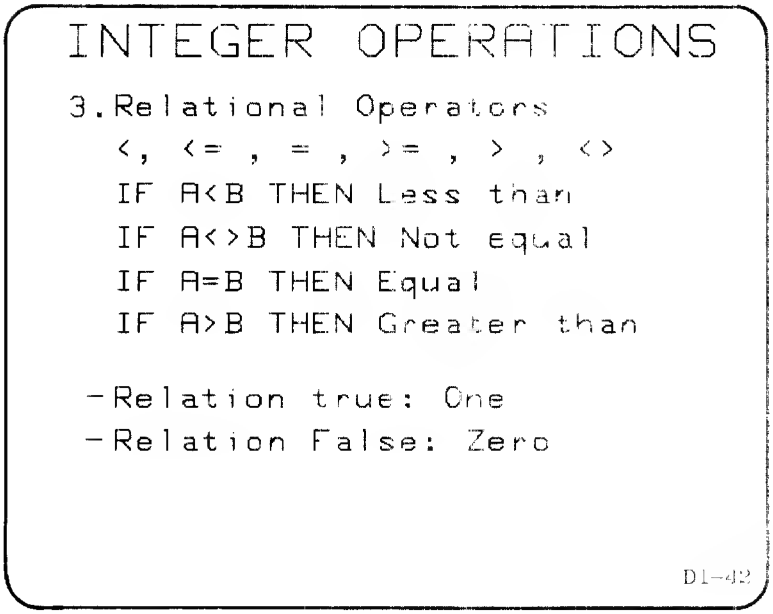
```
A= ABS(B)            Absolute value
A= SGN(B)              Sign (-1,0,1)
A= INT(3.14159)        Integer part
```

The integer value of any number is the next lower whole number!

```
INT(3.14159) = 3
INT(-3.14159) = -4
```

D1-41

NOTES



INTEGER OPERATIONS

3. Relational Operators

```
<, <= , = , >= , > , <>
IF A<B THEN Less than
IF A<>B THEN Not equal
IF A=B THEN Equal
IF A>B THEN Greater than
```

- Relation true: One
- Relation False: Zero

D1-42

INTEGER OPERATIONS

4. Logical Operators

- AND, OR, NOT, EXOR

```
IF NOT(A>=B) THEN Less_than
IF (A<B) EXOR (C<D) THEN
                   Only_one_less
IF (A<B) AND (C<D) THEN
                      Both_less
```

AND

B

		0	1
A	0	0	0
	1	0	1

OR

B

		0	1
A	0	0	1
	1	1	1

EXOR

B

		0	1
A	0	0	1
	1	1	0

D1-43

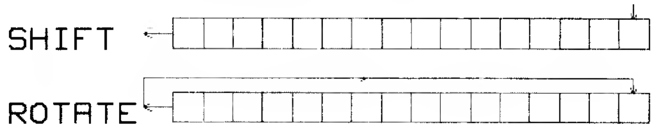
NOTES

INTEGER OPERATIONS

5. Binary Operations

- BINAND, BINIOR, BINCMP, BINEOR, SHIFT, ROTATE, BIT

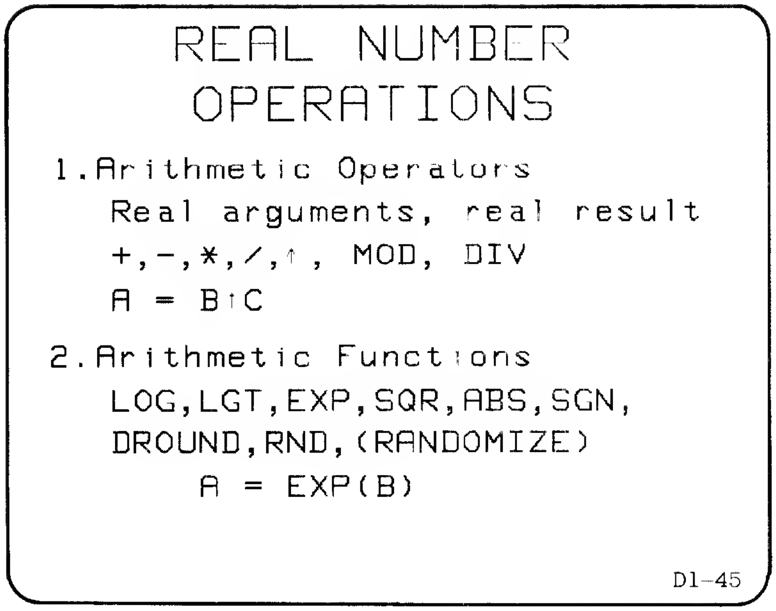
```
A = BINAND(B,C)
A = SHIFT(B,8)
IF BIT(A,2) THEN Bit_set
A = ROTATE(B,-8)              0
```



D1-44

NOTES

NOTES



REAL NUMBER OPERATIONS

1. Arithmetic Operators

   Real arguments, real result

   +, −, *, /, ↑, MOD, DIV

   A = B↑C

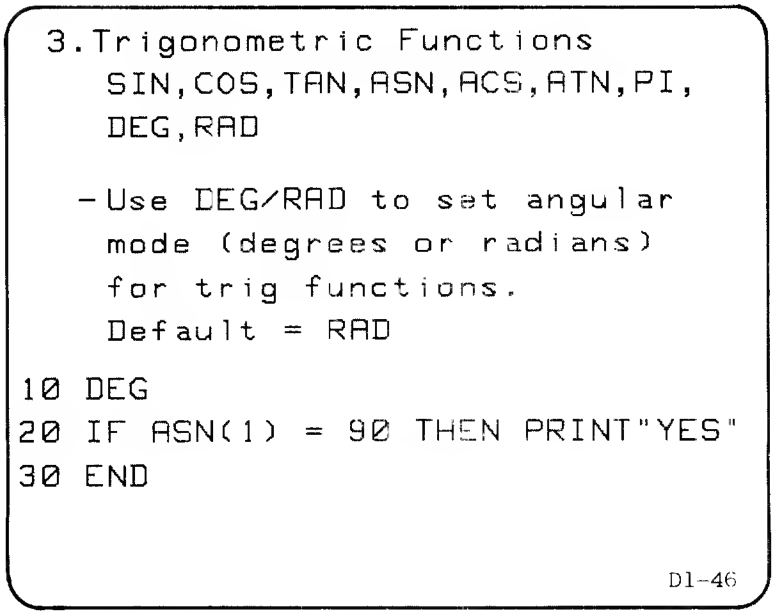
2. Arithmetic Functions

   LOG, LGT, EXP, SQR, ABS, SGN, DROUND, RND, (RANDOMIZE)

   A = EXP(B)

D1-45

NOTES



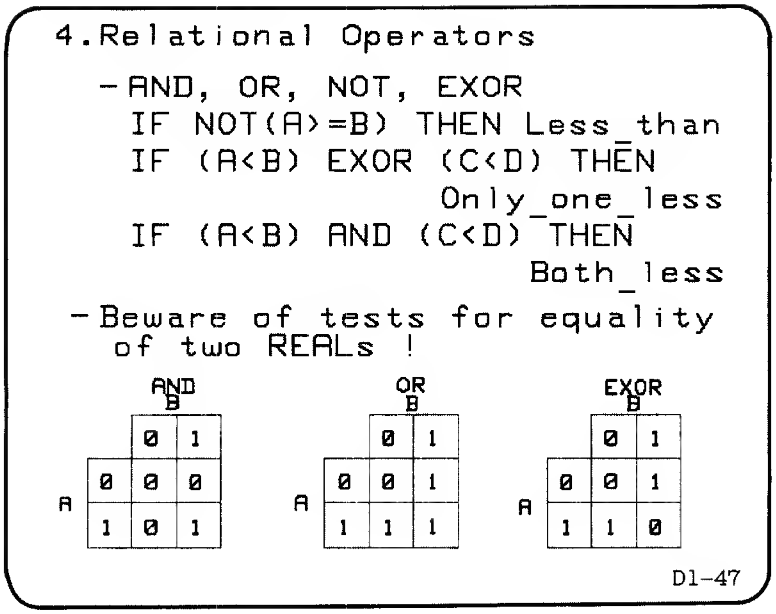
3. Trigonometric Functions

   SIN, COS, TAN, ASN, ACS, ATN, PI, DEG, RAD

   - Use DEG/RAD to set angular mode (degrees or radians) for trig functions. Default = RAD

```
10 DEG
20 IF ASN(1) = 90 THEN PRINT"YES"
30 END
```

D1-46



4.Relational Operators

- AND, OR, NOT, EXOR

```
IF NOT(A>=B) THEN Less_than
IF (A<B) EXOR (C<D) THEN
                    Only_one_less
IF (A<B) AND (C<D) THEN
                          Both_less
```

- Beware of tests for equality of two REALs !

AND

		B	
		0	1
A	0	0	0
	1	0	1

OR

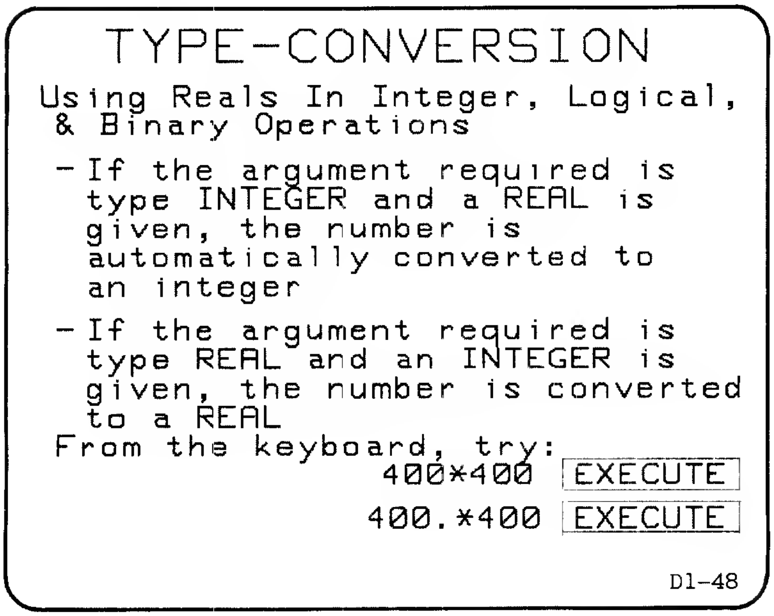
		B	
		0	1
A	0	0	1
	1	1	1

EXOR

		B	
		0	1
A	0	0	1
	1	1	0

D1-47

NOTES



TYPE-CONVERSION

Using Reals In Integer, Logical, & Binary Operations

- If the argument required is type INTEGER and a REAL is given, the number is automatically converted to an integer
- If the argument required is type REAL and an INTEGER is given, the number is converted to a REAL

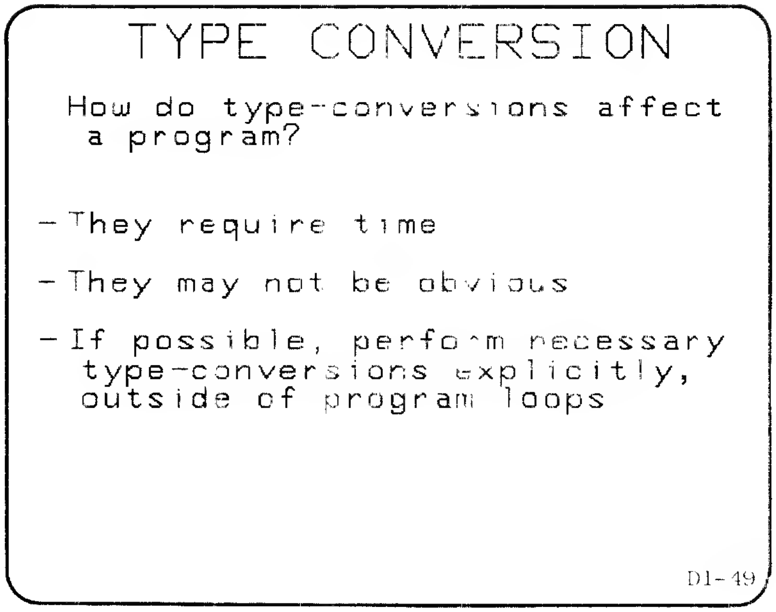
From the keyboard, try:

```
 400*400  EXECUTE
400.*400  EXECUTE
```

D1-48

NOTES

NOTES



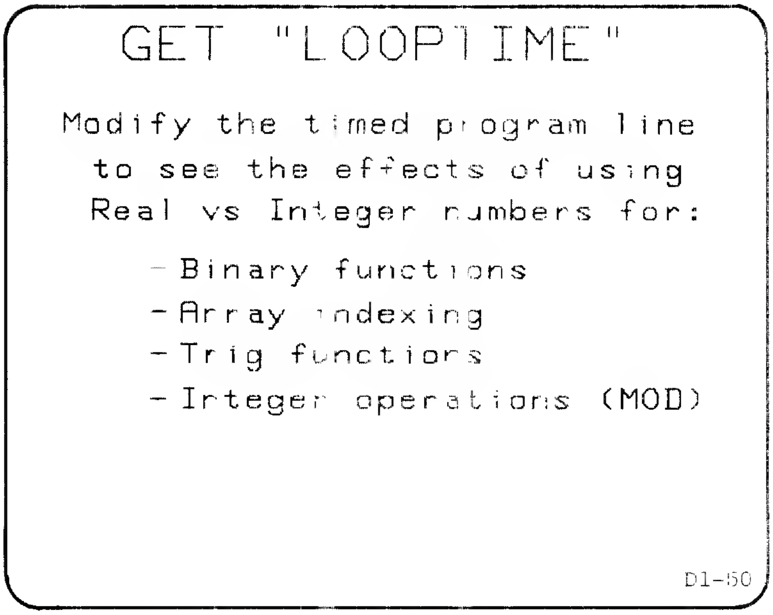
TYPE CONVERSION

How do type-conversions affect a program?

- They require time
- They may not be obvious
- If possible, perform necessary type-conversions explicitly, outside of program loops

D1-49

NOTES



GET "LOOPTIME"

Modify the timed program line to see the effects of using Real vs Integer numbers for:

- Binary functions
- Array indexing
- Trig functions
- Integer operations (MOD)

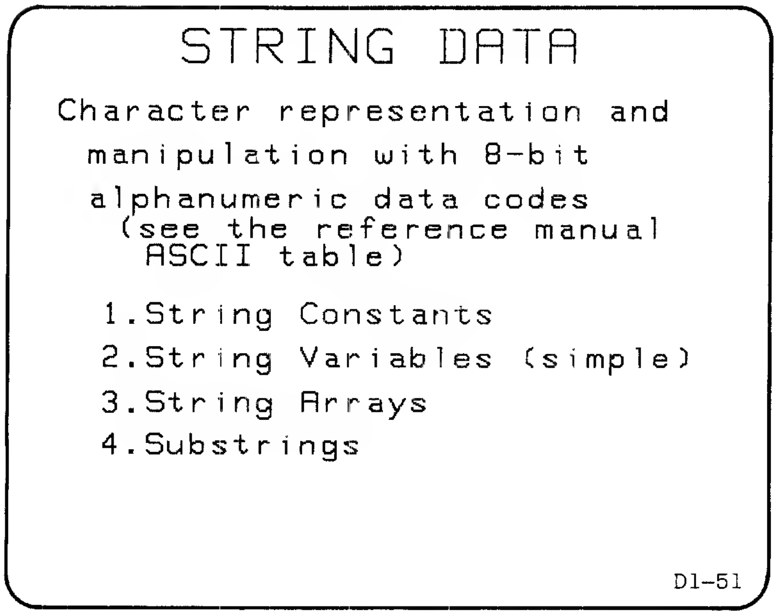
D1-50

"LOOPTIME"

1. Modify Line 130 to time various statements. Some examples are:

```
130 A(One) = PI              !Integer array index.
130 A(Four) = PI             !Real array index
130 IF  One THEN 140         !Integer relational
130 IF Four THEN 140         !Real relational
130 Four = Five + Six        !Real add, no convert
130 One = Five + Six         !Real add,convert
130 One = BINAND (Two,Three) !Intgr op,Intgrs.
130 Four = BINAND (Five,Six) !Intgr op,Reals
```

2. Now GET "FINDMAX" and follow directions listed in the program.



STRING DATA

Character representation and manipulation with 8-bit alphanumeric data codes (see the reference manual ASCII table)

1. String Constants
2. String Variables (simple)
3. String Arrays
4. Substrings

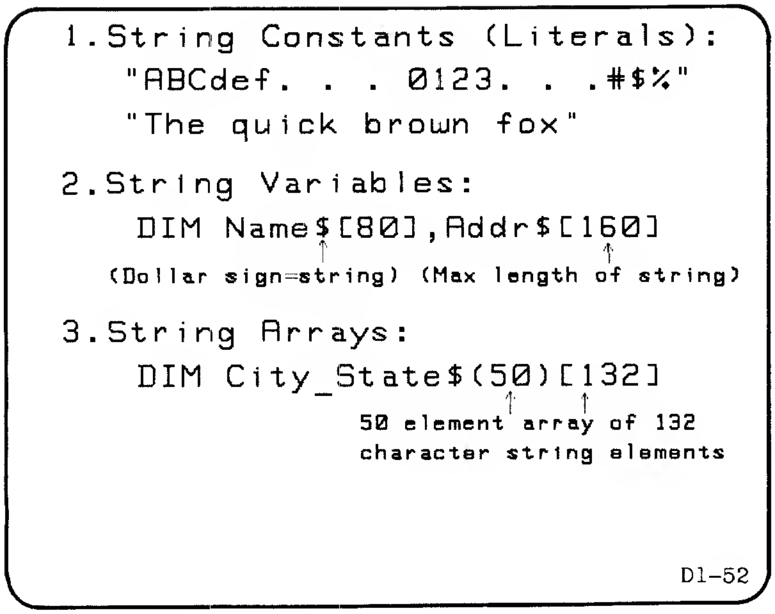
D1-51

NOTES

US ASCII Character Codes

ASCII Char	EQUIVALENT FORMS			
	Binary	Oct	Hex	Dec
NULL	00000000	000	00	0
SOH	00000001	001	01	1
STX	00000010	002	02	2
ETX	00000011	003	03	3
EOT	00000100	004	04	4
ENQ	00000101	005	05	5
ACK	00000110	006	06	6
BELL	00000111	007	07	7
BS	00001000	010	08	8
HT	00001001	011	09	9
LF	00001010	012	0A	10
VT	00001011	013	0B	11
FF	00001100	014	0C	12
CR	00001101	015	0D	13
SO	00001110	016	0E	14
SI	00001111	017	0F	15
DLE	00010000	020	10	16
DC1	00010001	021	11	17
DC2	00010010	022	12	18
DC3	00010011	023	13	19
DC4	00010100	024	14	20
NAK	00010101	025	15	21
SYNC	00010110	026	16	22
ETB	00010111	027	17	23
CAN	00011000	030	18	24
EM	00011001	031	19	25
SUB	00011010	032	1A	26
ESC	00011011	033	1B	27
FS	00011100	034	1C	28
GS	00011101	035	1D	29
RS	00011110	036	1E	30
US	00011111	037	1F	31
space	00100000	040	20	32
!	00100001	041	21	33
"	00100010	042	22	34
#	00100011	043	23	35
$	00100100	044	24	36
%	00100101	045	25	37
&	00100110	046	26	38
'	00100111	047	27	39
(	00101000	050	28	40
)	00101001	051	29	41
*	00101010	052	2A	42
+	00101011	053	2B	43
,	00101100	054	2C	44
-	00101101	055	2D	45
.	00101110	056	2E	46
/	00101111	057	2F	47
0	00110000	060	30	48
1	00110001	061	31	49
2	00110010	062	32	50
3	00110011	063	33	51
4	00110100	064	34	52
5	00110101	065	35	53
6	00110110	066	36	54
7	00110111	067	37	55
8	00111000	070	38	56
9	00111001	071	39	57
:	00111010	072	3A	58
;	00111011	073	3B	59
<	00111100	074	3C	60
=	00111101	075	3D	61
>	00111110	076	3E	62
?	00111111	077	3F	63
@	01000000	100	40	64
A	01000001	101	41	65
B	01000010	102	42	66
C	01000011	103	43	67
D	01000100	104	44	68
E	01000101	105	45	69
F	01000110	106	46	70
G	01000111	107	47	71
H	01001000	110	48	72
I	01001001	111	49	73
J	01001010	112	4A	74
K	01001011	113	4B	75
L	01001100	114	4C	76
M	01001101	115	4D	77
N	01001110	116	4E	78
O	01001111	117	4F	79
P	01010000	120	50	80
Q	01010001	121	51	81
R	01010010	122	52	82
S	01010011	123	53	83
T	01010100	124	54	84
U	01010101	125	55	85
V	01010110	126	56	86
W	01010111	127	57	87
X	01011000	130	58	88
Y	01011001	131	59	89
Z	01011010	132	5A	90
[	01011011	133	5B	91
\	01011100	134	5C	92
]	01011101	135	5D	93
^	01011110	136	5E	94
	01011111	137	5F	95
`	01100000	140	60	96
a	01100001	141	61	97
b	01100010	142	62	98
c	01100011	143	63	99
d	01100100	144	64	100
e	01100101	145	65	101
f	01100110	146	66	102
g	01100111	147	67	103
h	01101000	150	68	104
i	01101001	151	69	105
j	01101010	152	6A	106
k	01101011	153	6B	107
l	01101100	154	6C	108
m	01101101	155	6D	109
n	01101110	156	6E	110
o	01101111	157	6F	111
p	01110000	160	70	112
q	01110001	161	71	113
r	01110010	162	72	114
s	01110011	163	73	115
t	01110100	164	74	116
u	01110101	165	75	117
v	01110110	166	76	118
w	01110111	167	77	119
x	01111000	170	78	120
y	01111001	171	79	121
z	01111010	172	7A	122
{	01111011	173	7B	123
|	01111100	174	7C	124
}	01111101	175	7D	125
~	01111110	176	7E	126
DEL	01111111	177	7F	127

STD-LL 60061



1. String Constants (Literals):

```
"ABCdef. . . 0123. . .#$%"
"The quick brown fox"
```

2. String Variables:

```
DIM Name$[80],Addr$[160]
```

(Dollar sign=string) (Max length of string)

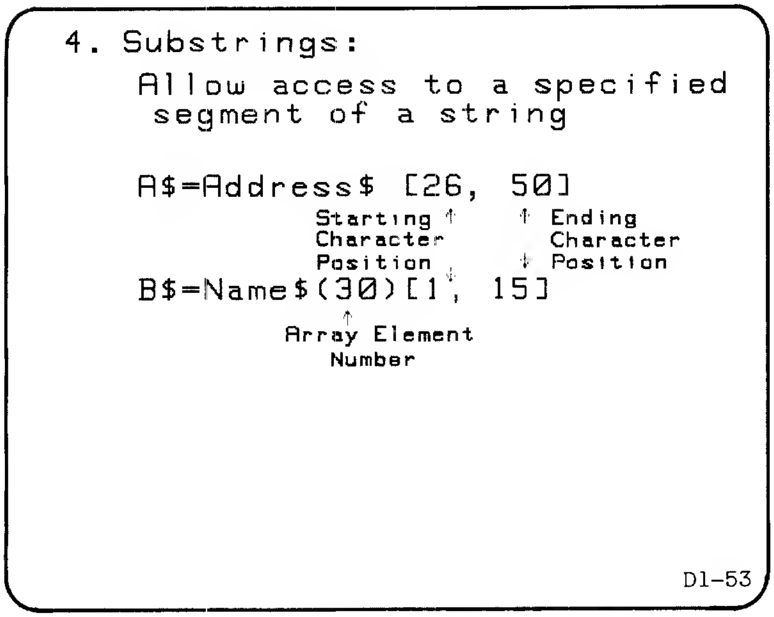
3. String Arrays:

```
DIM City_State$(50)[132]
```

50 element array of 132 character string elements

D1-52

NOTES



4. Substrings:

Allow access to a specified segment of a string

```
A$=Address$ [26, 50]
```

Starting Character Position

Ending Character Position

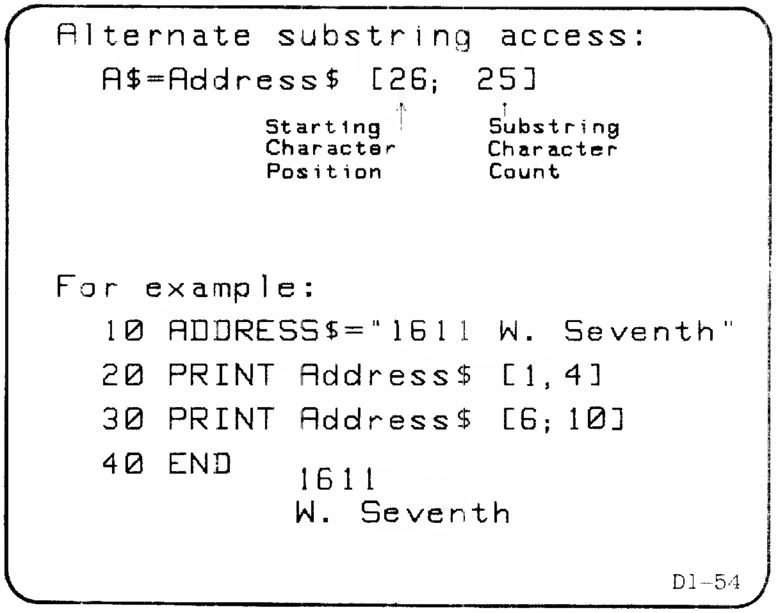
```
B$=Name$(30)[1, 15]
```

Array Element Number

D1-53

NOTES

NOTES



Alternate substring access:

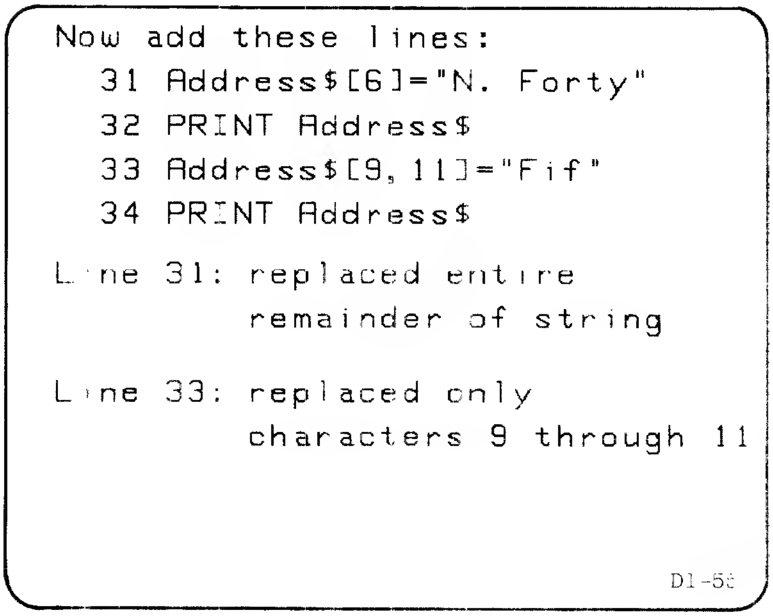
```
  A$=Address$ [26;  25]
                 ↑     ↑
   Starting         Substring
   Character        Character
   Position         Count
```

For example:

```
  10 ADDRESS$="1611 W. Seventh"
  20 PRINT Address$ [1,4]
  30 PRINT Address$ [6;10]
  40 END   1611
           W. Seventh
```

D1-54

NOTES



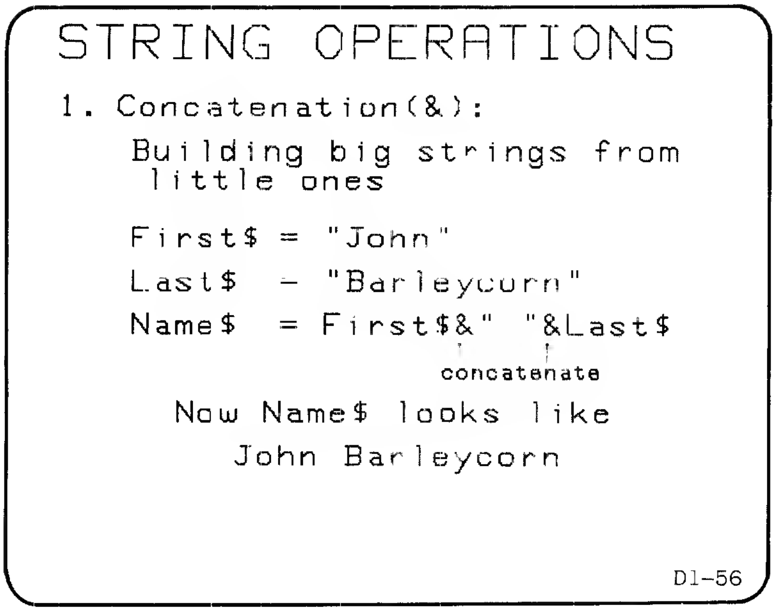
Now add these lines:

```
  31 Address$[6]="N. Forty"
  32 PRINT Address$
  33 Address$[9,11]="Fif"
  34 PRINT Address$
```

Line 31: replaced entire remainder of string

Line 33: replaced only characters 9 through 11

D1-55



STRING OPERATIONS

1. Concatenation(&):

Building big strings from little ones

```
First$ = "John"
Last$  - "Barleycorn"
Name$  = First$&" "&Last$
```

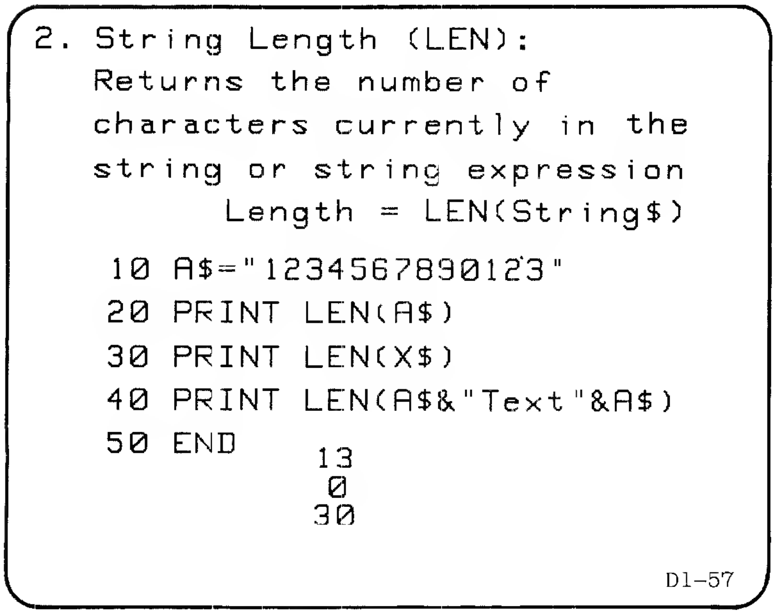
concatenate

Now Name$ looks like

John Barleycorn

D1-56

NOTES



2. String Length (LEN):

Returns the number of characters currently in the string or string expression

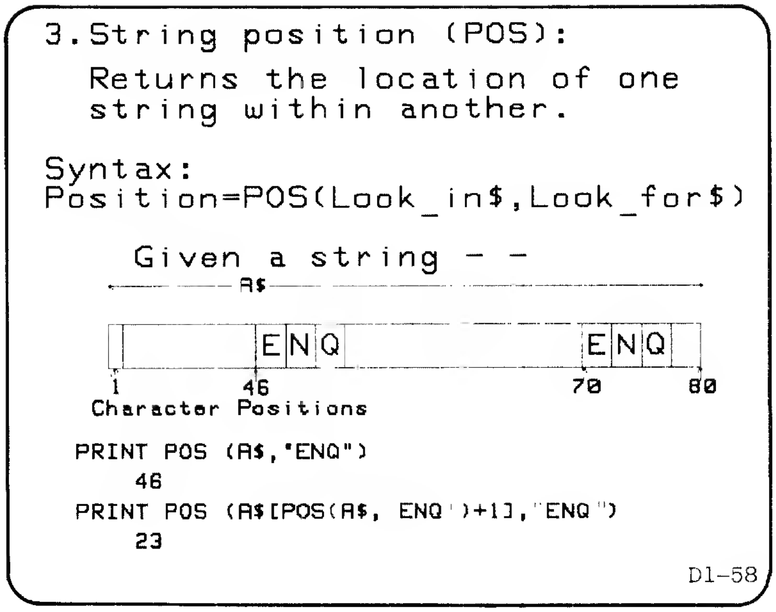
Length = LEN(String$)

```
10 A$="1234567890123"
20 PRINT LEN(A$)
30 PRINT LEN(X$)
40 PRINT LEN(A$&"Text"&A$)
50 END
          13
           0
          30
```

D1-57

NOTES

NOTES



3.String position (POS):

Returns the location of one string within another.

Syntax:
```
Position=POS(Look_in$,Look_for$)
```

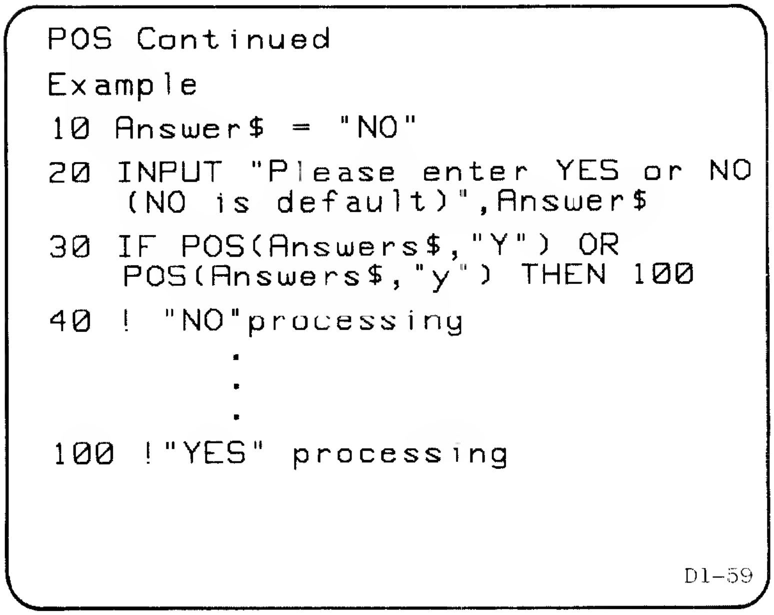
Given a string - -

A$
E N Q
E N Q
1
46
70
80
Character Positions

```
PRINT POS (A$,"ENQ")
    46
PRINT POS (A$[POS(A$, ENQ' )+1],"ENQ")
    23
```

D1-58

NOTES

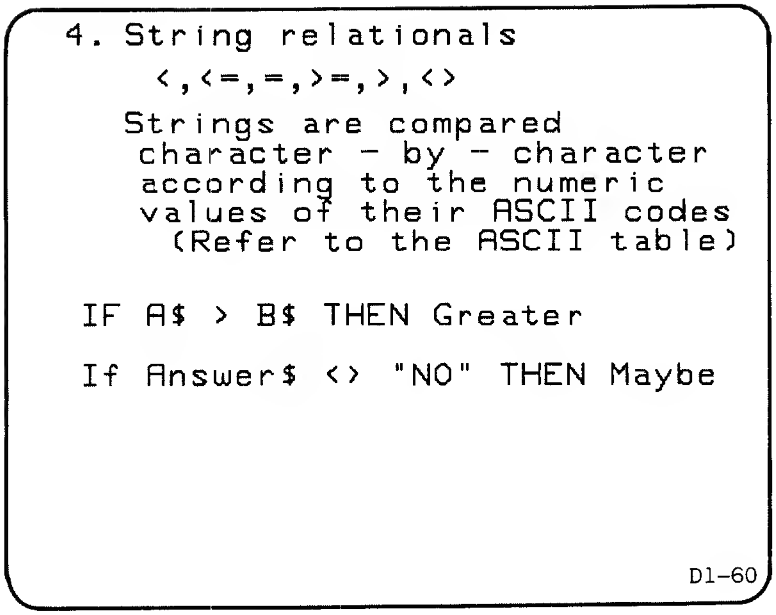


POS Continued

Example

```
10 Answer$ = "NO"
20 INPUT "Please enter YES or NO
    (NO is default)",Answer$
30 IF POS(Answers$,"Y") OR
    POS(Answers$,"y") THEN 100
40 ! "NO"processing
          .
          .
          .
100 !"YES" processing
```

D1-59



4. String relationals

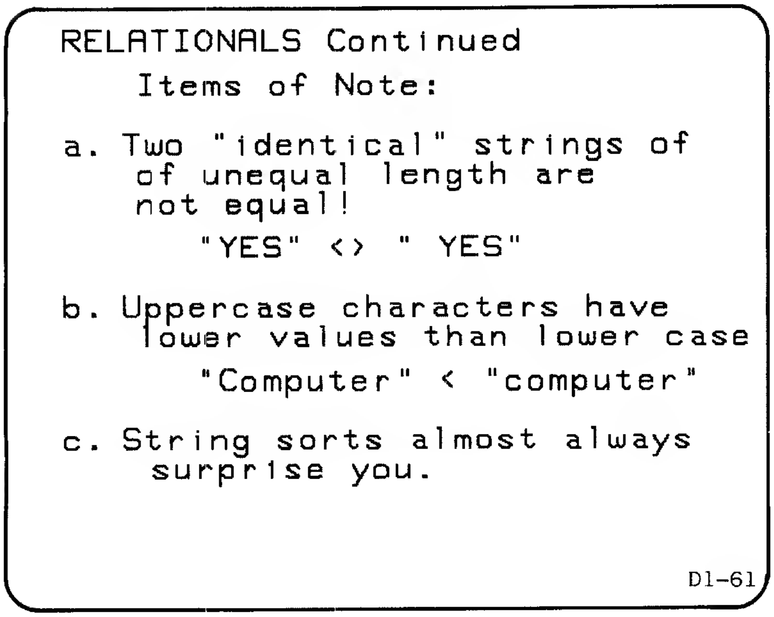
   <,<=,=,>=,>,<>

   Strings are compared character - by - character according to the numeric values of their ASCII codes (Refer to the ASCII table)

```
IF A$ > B$ THEN Greater

If Answer$ <> "NO" THEN Maybe
```

D1-60

NOTES



RELATIONALS Continued

Items of Note:

a. Two "identical" strings of unequal length are not equal!

   "YES" <> " YES"

b. Uppercase characters have lower values than lower case

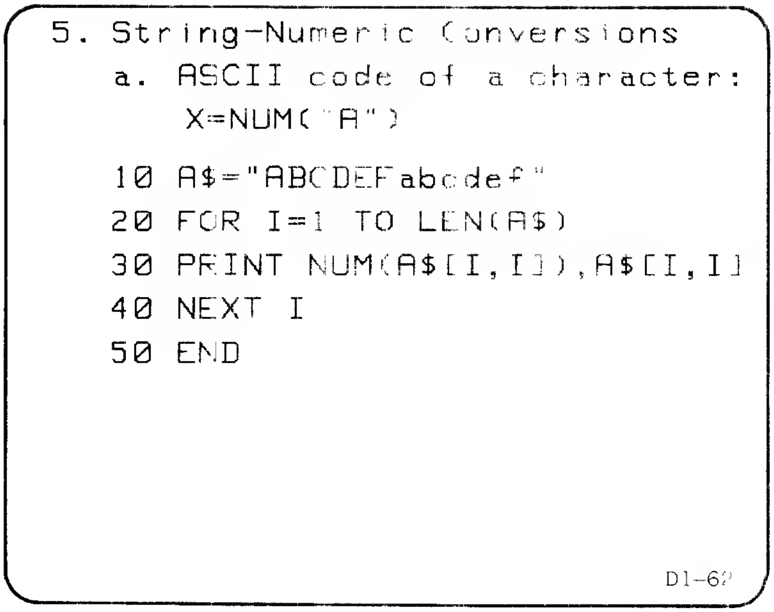
   "Computer" < "computer"

c. String sorts almost always surprise you.

D1-61

NOTES

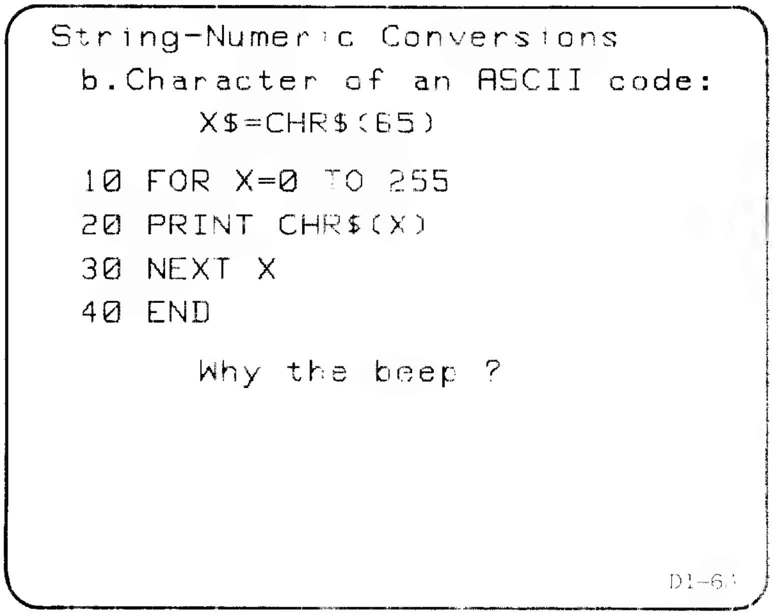
NOTES



```
5. String-Numeric Conversions
   a. ASCII code of a character:
      X=NUM("A")

   10 A$="ABCDEFabcdef"
   20 FOR I=1 TO LEN(A$)
   30 PRINT NUM(A$[I,I]),A$[I,I]
   40 NEXT I
   50 END
```

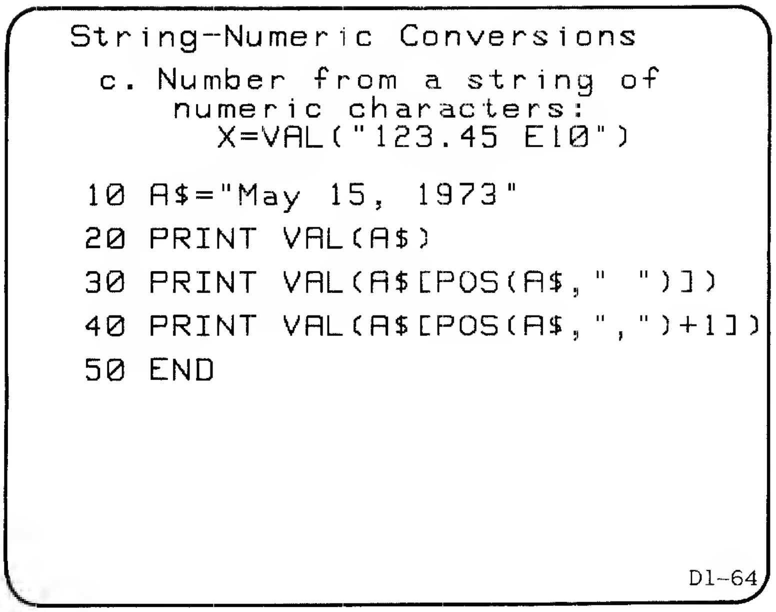
D1-62

NOTES



```
String-Numeric Conversions
 b.Character of an ASCII code:
      X$=CHR$(65)

 10 FOR X=0 TO 255
 20 PRINT CHR$(X)
 30 NEXT X
 40 END

      Why the beep ?
```

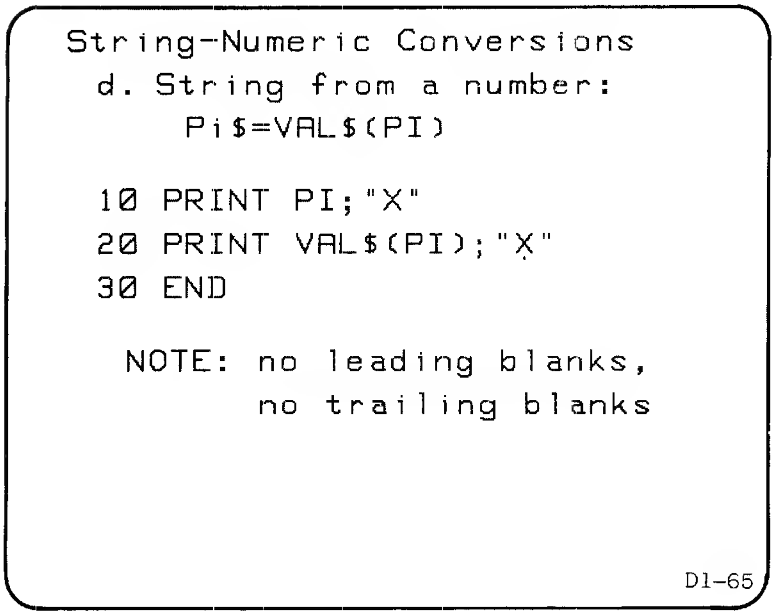
D1-63



```
String-Numeric Conversions
 c. Number from a string of
    numeric characters:
      X=VAL("123.45 E10")

10 A$="May 15, 1973"
20 PRINT VAL(A$)
30 PRINT VAL(A$[POS(A$," ")])
40 PRINT VAL(A$[POS(A$,",")+1])
50 END
```

D1-64

NOTES



```
String-Numeric Conversions
 d. String from a number:
     Pi$=VAL$(PI)

 10 PRINT PI;"X"
 20 PRINT VAL$(PI);"X"
 30 END

  NOTE: no leading blanks,
        no trailing blanks
```

D1-65

NOTES

EXERCISE 1

Write a program that accepts an input of the form MM/DD/YY and converts it to the corresponding month, day, and year in the form Month Day,Year. For example:

Input= 06/21/81

Output= June 21, 1981

1. Use string array to hold the names of the months, then index into the array with the number of the month that was input.

2. Use the POS function and substrings to extract the day and the year information from the input string.

3. Consider the difference between the following two statements, where A$ is "ab/cd/ef" :

```
X = POS(A$, "/")
Y = POS(A$[4],"/")
X = 3, Y = 2
```

EXERCISE 2

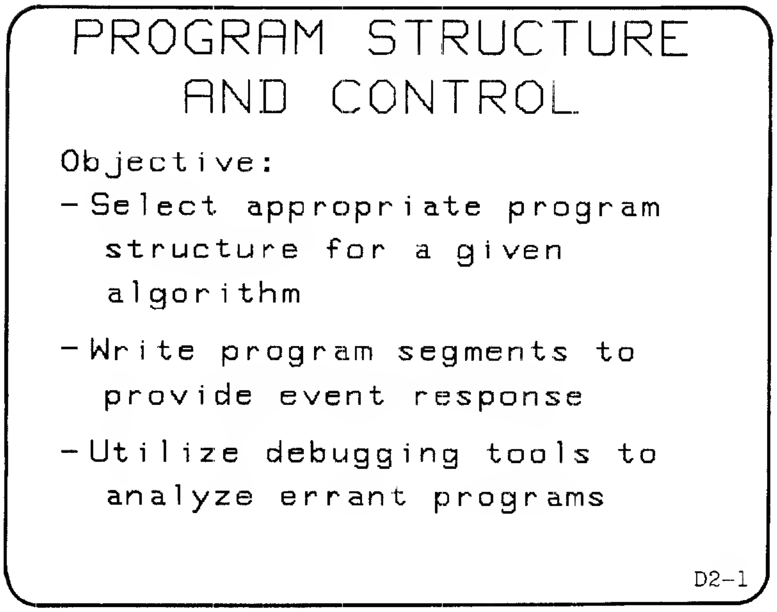
Write a search-and-replace subroutine that replaces all occurrences of a "seek for" string with a "replace with" string. The subroutine will look in a string array for strings to replace. Print out any string elements your routine modifies.

Save your subroutine on disc (SAVE"TEMP"), then GET "SCH_RPL" , then append your subroutine to the end of the program SCH_RPL. Remember to include an END statement at the end of the program then try it out.

```
Your subroutine's name : Search_replace
The string array's name: Search_in$
Number of elements in Search_in $ : Num_elem
```

Example Subroutine format:

```
 10 Search_replace : ! This subroutine searches for ...
 20    INPUT "Search string?", A$
        .
        .
        .
110 RETURN
```



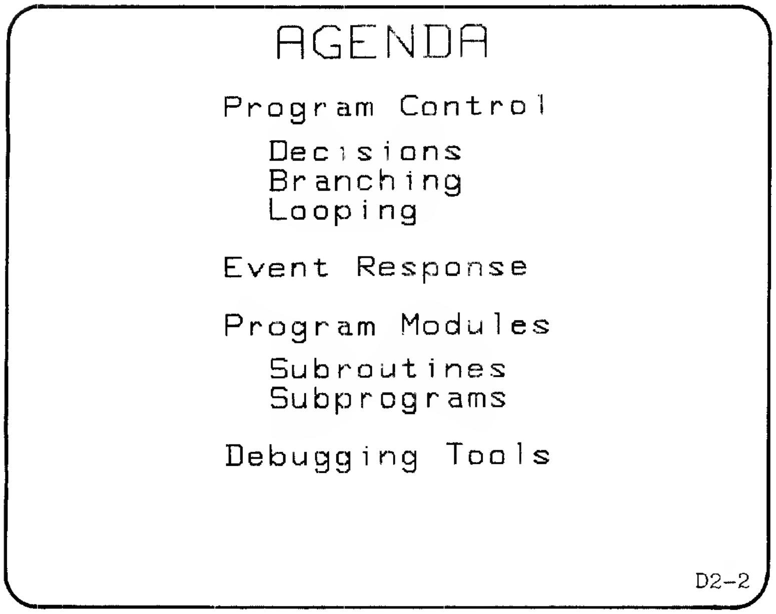
PROGRAM STRUCTURE AND CONTROL

Objective:

- Select appropriate program structure for a given algorithm
- Write program segments to provide event response
- Utilize debugging tools to analyze errant programs

D2-1

NOTES



AGENDA

Program Control

Decisions
Branching
Looping

Event Response

Program Modules

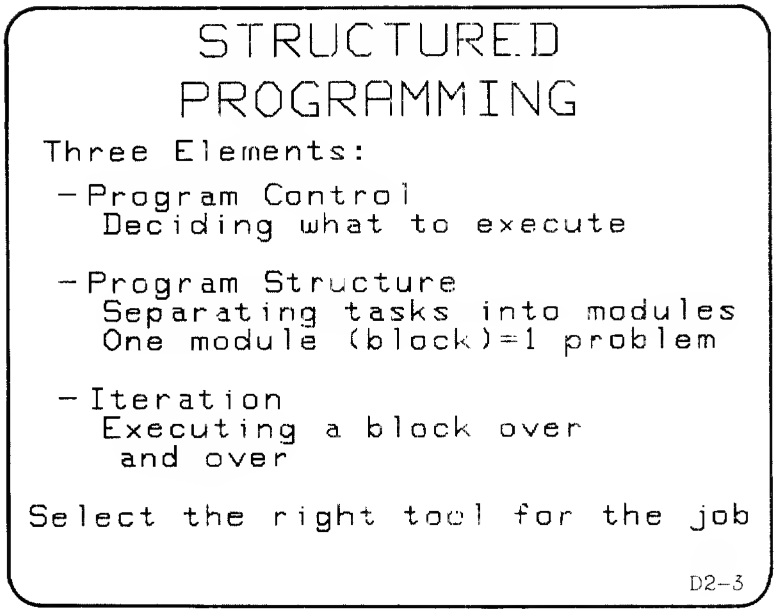
Subroutines
Subprograms

Debugging Tools

D2-2

NOTES

NOTES



STRUCTURED PROGRAMMING

Three Elements:

- Program Control
  Deciding what to execute

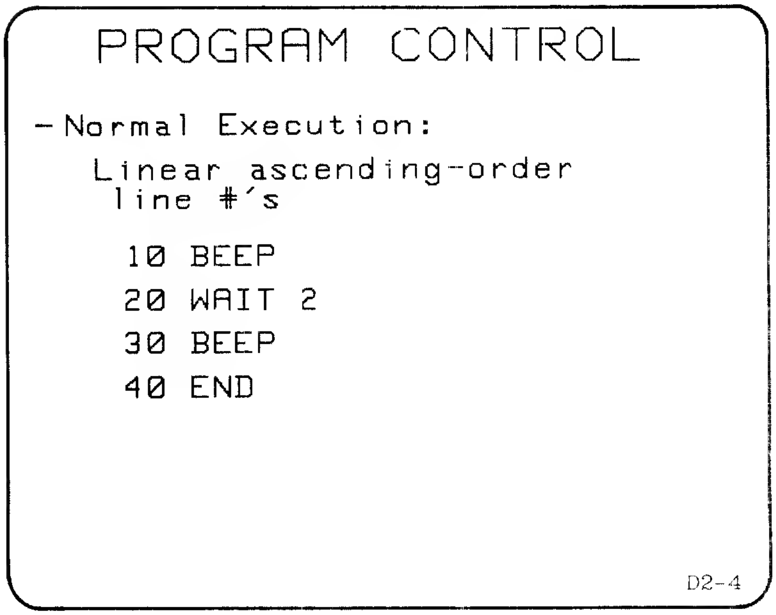
- Program Structure
  Separating tasks into modules
  One module (block)=1 problem

- Iteration
  Executing a block over
  and over

Select the right tool for the job

D2-3

NOTES



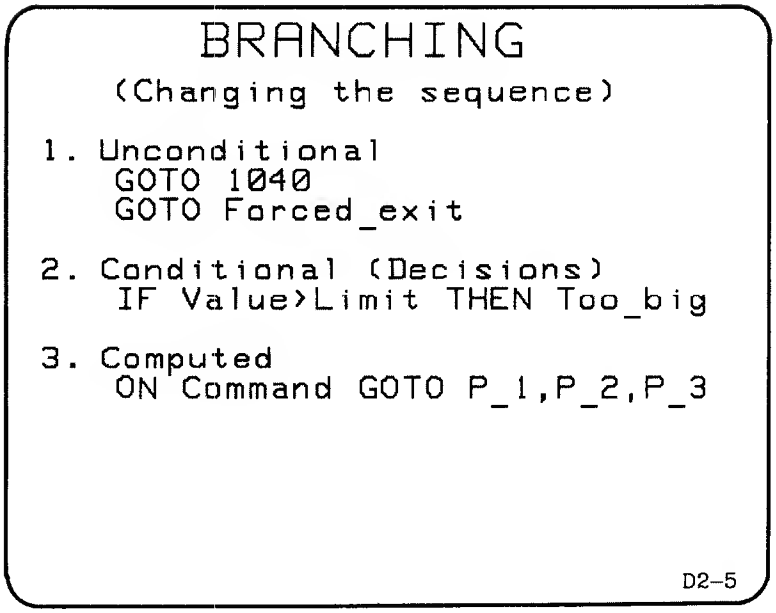
PROGRAM CONTROL

- Normal Execution:

  Linear ascending-order
  line #'s

```
10 BEEP
20 WAIT 2
30 BEEP
40 END
```

D2-4



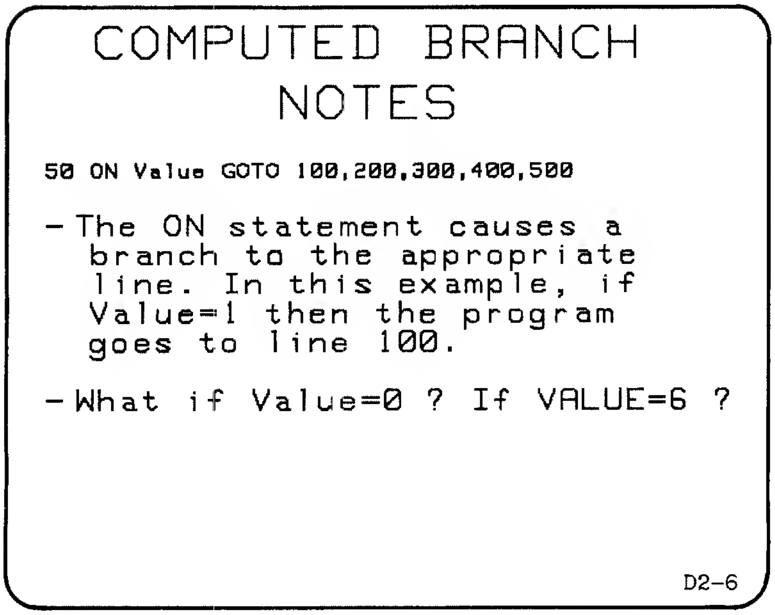
BRANCHING

(Changing the sequence)

1. Unconditional
```
GOTO 1040
GOTO Forced_exit
```
2. Conditional (Decisions)
```
IF Value>Limit THEN Too_big
```
3. Computed
```
ON Command GOTO P_1,P_2,P_3
```

D2-5

NOTES



COMPUTED BRANCH NOTES

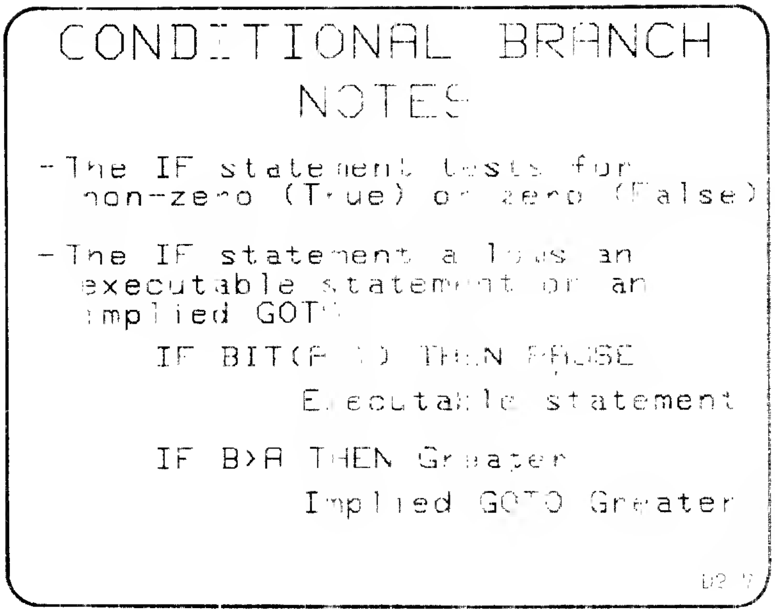
```
50 ON Value GOTO 100,200,300,400,500
```

- The ON statement causes a branch to the appropriate line. In this example, if Value=1 then the program goes to line 100.
- What if Value=0 ? If VALUE=6 ?

D2-6

NOTES

NOTES



CONDITIONAL BRANCH NOTES

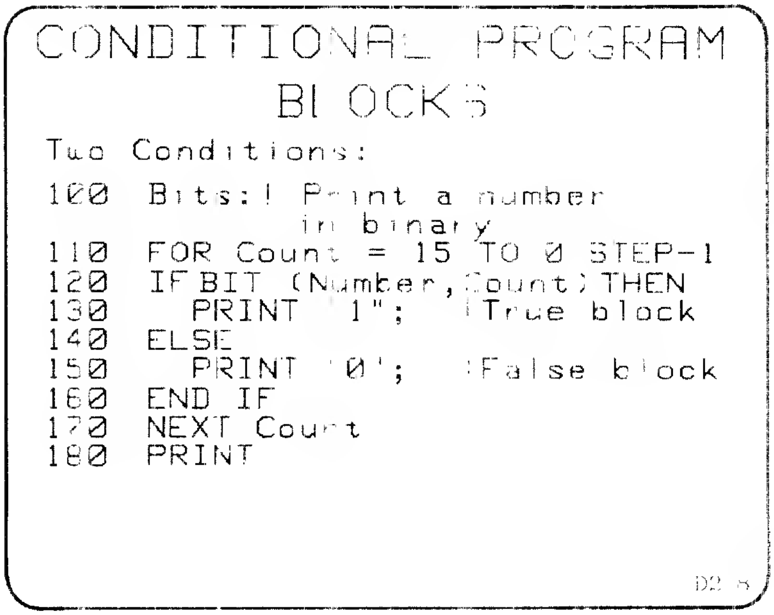
- The IF statement tests for non-zero (True) or zero (False)

- The IF statement allows an executable statement or an implied GOTO

```
    IF BIT(A,0) THEN PAUSE
        Executable statement

    IF B>A THEN Greater
        Implied GOTO Greater
```

D2-7

NOTES

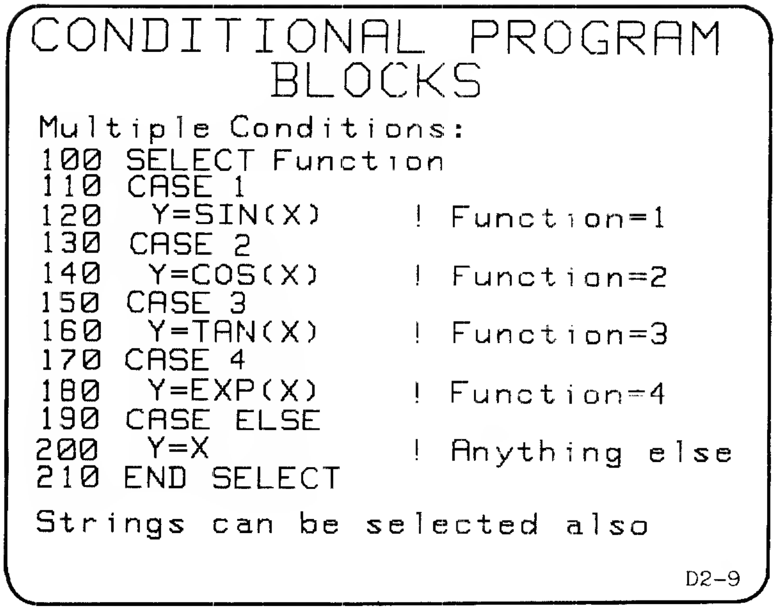


CONDITIONAL PROGRAM BLOCKS

Two Conditions:

```
100  Bits:! Print a number
                in binary
110  FOR Count = 15 TO Ø STEP-1
120  IF BIT (Number,Count) THEN
130    PRINT "1";   !True block
140  ELSE
150    PRINT "Ø";   !False block
160  END IF
170  NEXT Count
180  PRINT
```

D2-8



CONDITIONAL PROGRAM BLOCKS

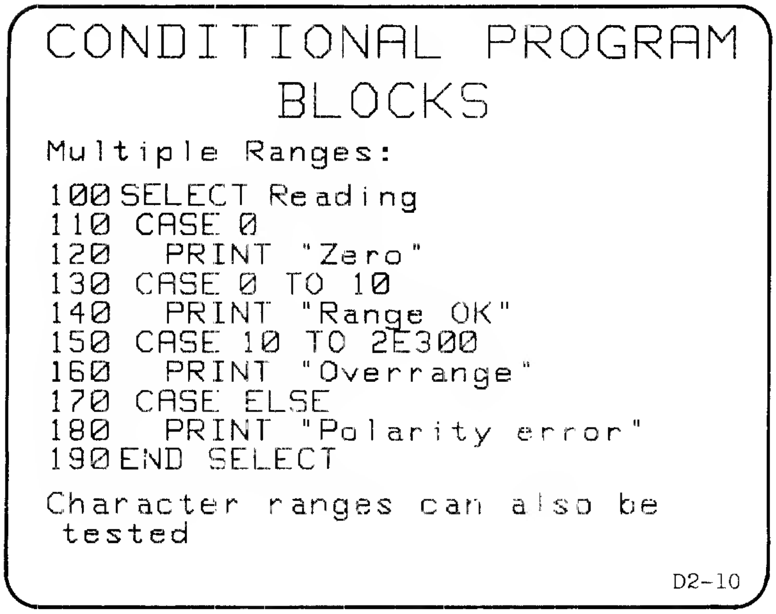
Multiple Conditions:

```
100 SELECT Function
110 CASE 1
120   Y=SIN(X)      ! Function=1
130 CASE 2
140   Y=COS(X)      ! Function=2
150 CASE 3
160   Y=TAN(X)      ! Function=3
170 CASE 4
180   Y=EXP(X)      ! Function=4
190 CASE ELSE
200   Y=X           ! Anything else
210 END SELECT
```

Strings can be selected also

D2-9

NOTES



CONDITIONAL PROGRAM BLOCKS

Multiple Ranges:

```
100 SELECT Reading
110 CASE 0
120   PRINT "Zero"
130 CASE 0 TO 10
140   PRINT "Range OK"
150 CASE 10 TO 2E300
160   PRINT "Overrange"
170 CASE ELSE
180   PRINT "Polarity error"
190 END SELECT
```

Character ranges can also be tested

D2-10

NOTES

EXERCISE 3

Write a program that uses the SELECT CASE structure to write the binary representation of a number. You can take the basic contents of the IF/THEN/ELSE and modify it to be a SELECT/CASE if you wish.

EXERCISE 4

Write a program to input a string of mixed uppercase and lowercase characters then convert that string to all uppercase characters. Use the SELECT/CASE construct to determine whether the character being analyzed is upper or lower case, and subtract 32 from the ASCII code of any characters in the range of "a" to "z:.

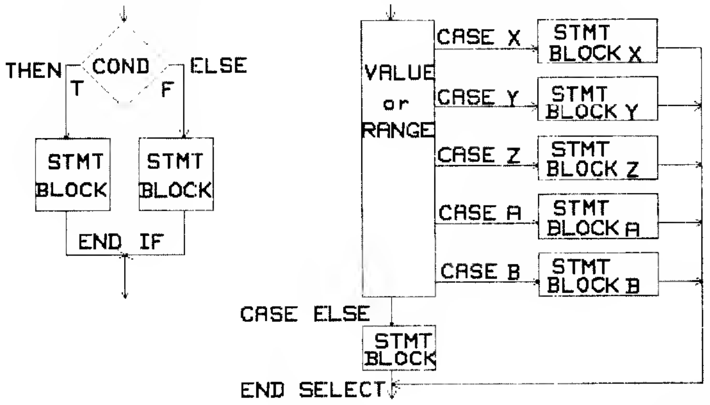
```
 Input : Yes
Output : YES
```

Modify the program to either convert the string to uppercase or to lowercase characters, depending upon the value of some variable. For example:

```
Function $ = "UPC"
   Input = no
  Output = NO

Function $ = "LWC"
   Input = WILDERNESS
  Output = wilderness
```

CONDITIONAL FLOW CHARTS (Program flow)

IF-THEN-ELSE SELECT-CASE



D2-11

NOTES

ITERATION

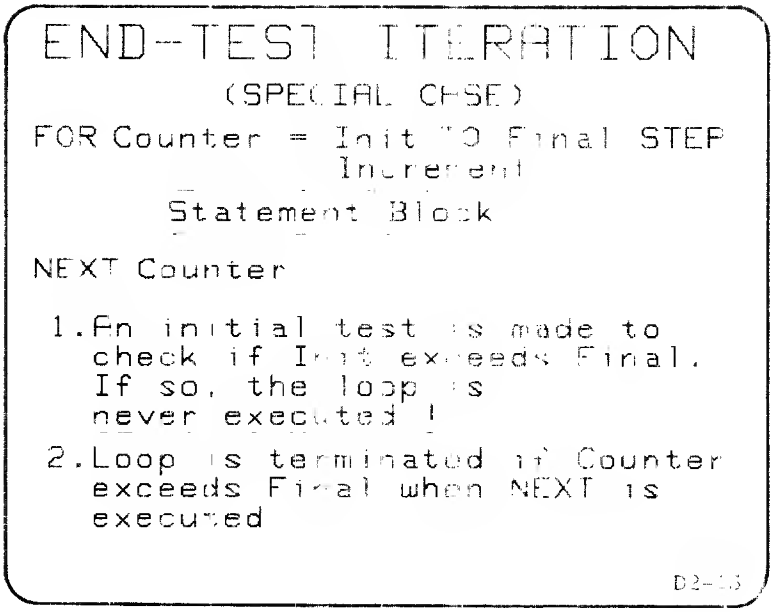
- Iteration is repetitive loop execution
- Termination test can occur in one (or more) of 3 places

1. Test at end of loop (always executes once)
2. Test at beginning of loop (may or may not execute loop)
3. Test in middle of loop (at least part of loop is executed)

D2-12

NOTES

NOTES



END-TEST ITERATION

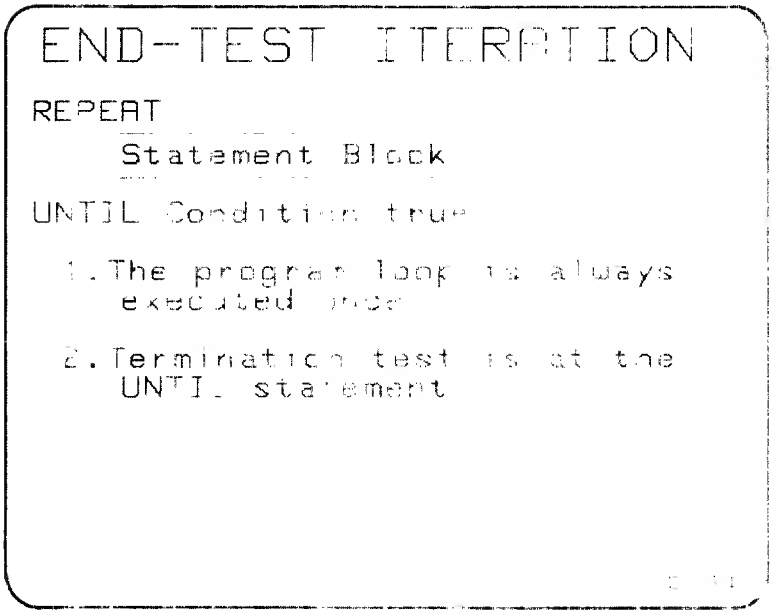
(SPECIAL CASE)

```
FOR Counter = Init TO Final STEP
                 Increment
      Statement Block
NEXT Counter
```

1. An initial test is made to check if Init exceeds Final. If so, the loop is never executed !
2. Loop is terminated if Counter exceeds Final when NEXT is executed

D2-13

NOTES



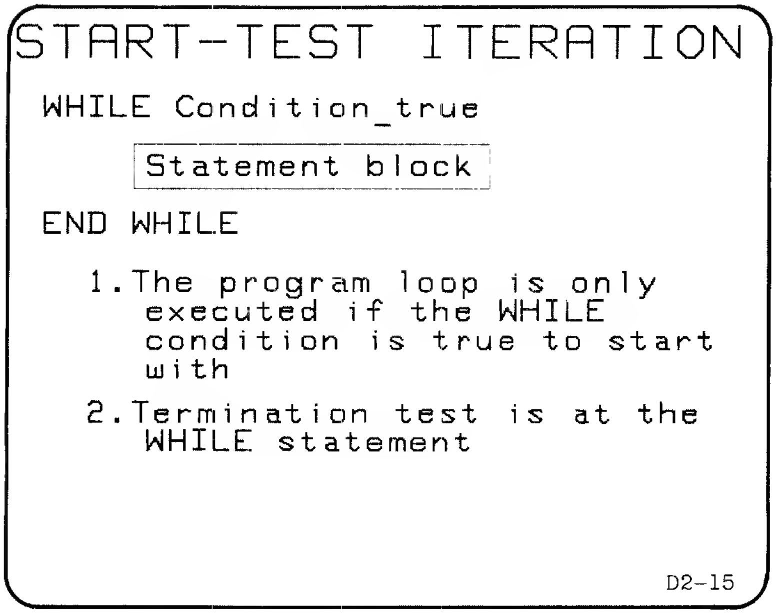
END-TEST ITERATION

```
REPEAT
    Statement Block
UNTIL Condition true
```

1. The program loop is always executed once
2. Termination test is at the UNTIL statement

EXERCISE 5

Rewrite the program that prints out the binary representation of a number, but use the REPEAT/UNTIL method of iteration instead of the FOR/NEXT loop.



START-TEST ITERATION

```
WHILE Condition_true
      Statement block
END WHILE
```

1. The program loop is only executed if the WHILE condition is true to start with
2. Termination test is at the WHILE statement

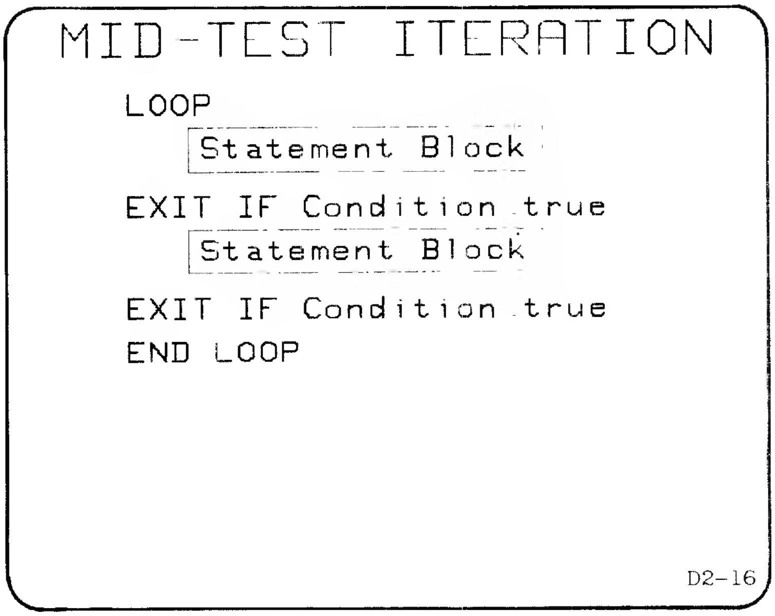
D2-15

NOTES

EXERCISE 6

Rewrite the program that prints out the binary representation of a number, but use the WHILE/ENDWHILE method of iteration instead of the FOR/NEXT loop. (Or simply modify the previous REPEAT program.)

NOTES



MID-TEST ITERATION

```
LOOP
    Statement Block
EXIT IF Condition true
    Statement Block
EXIT IF Condition true
END LOOP
```

D2-16

LOOP STATEMENT

1. Part of the loop is always executed unless an EXIT IF statement precedes the loop statement

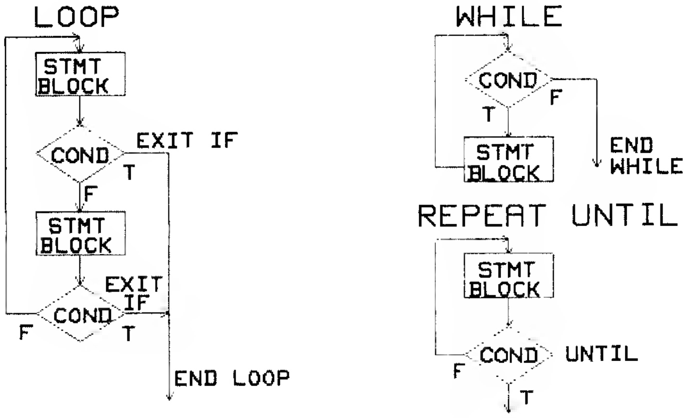
2. Termination test is at the EXIT IF statement

3. Multiple exit conditions can be programmed, as well as multiple exit points to break up the loop

D2-17

NOTES

LOOPING CONSTRUCT FLOW CHARTS


LOOP

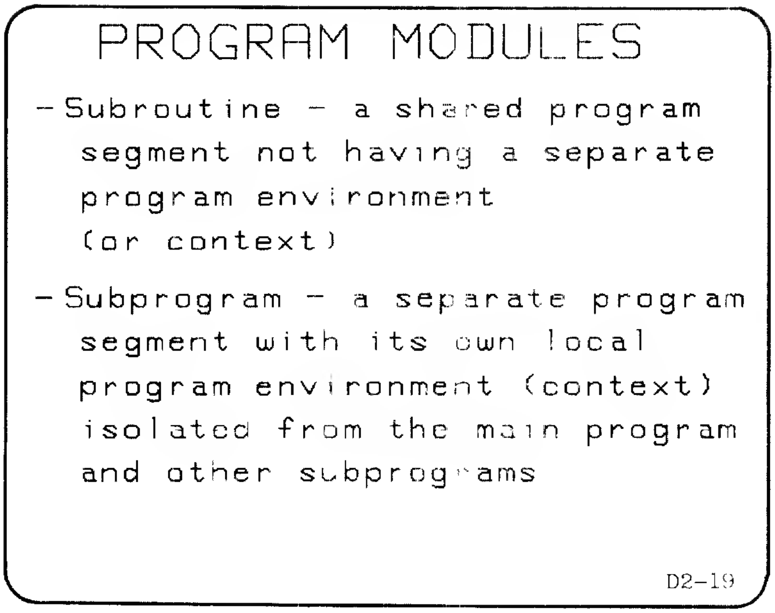
WHILE

REPEAT UNTIL

D2-18

NOTES

NOTES

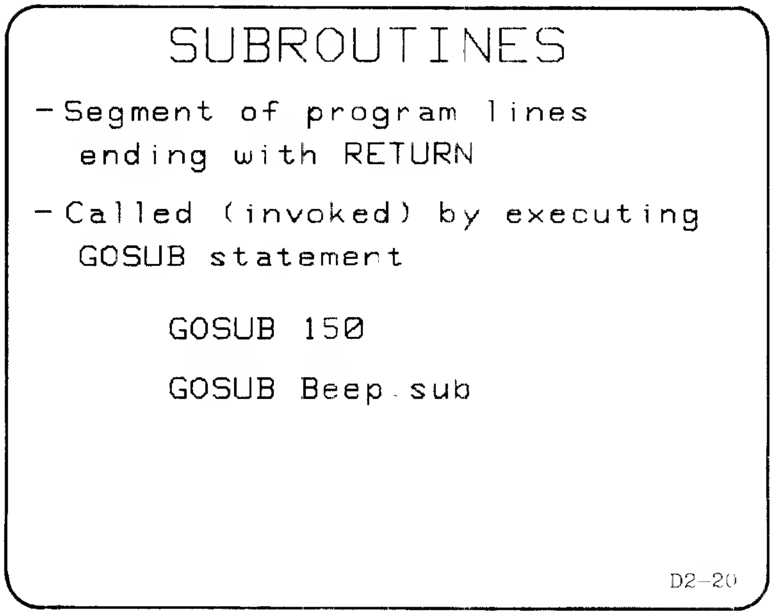


PROGRAM MODULES

- Subroutine – a shared program segment not having a separate program environment (or context)
- Subprogram – a separate program segment with its own local program environment (context) isolated from the main program and other subprograms

D2-19

NOTES

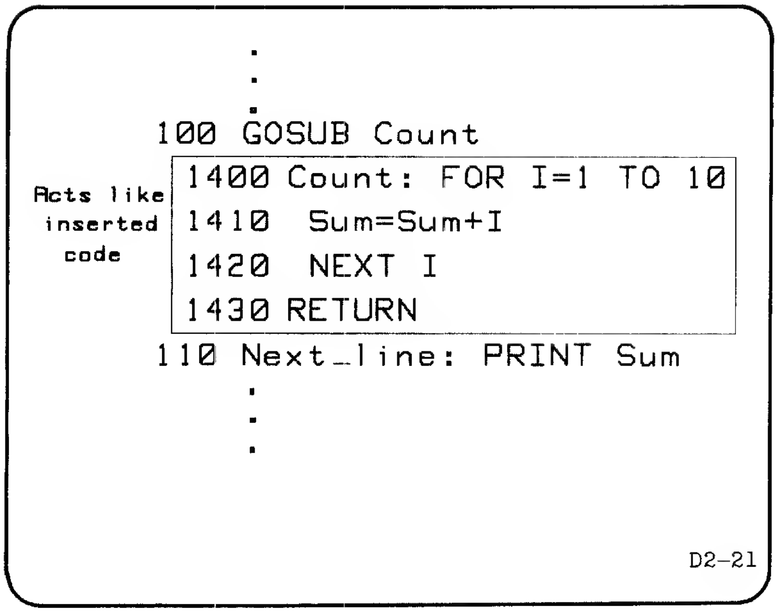


SUBROUTINES

- Segment of program lines ending with RETURN
- Called (invoked) by executing GOSUB statement

```
GOSUB 150

GOSUB Beep_sub
```

D2-20

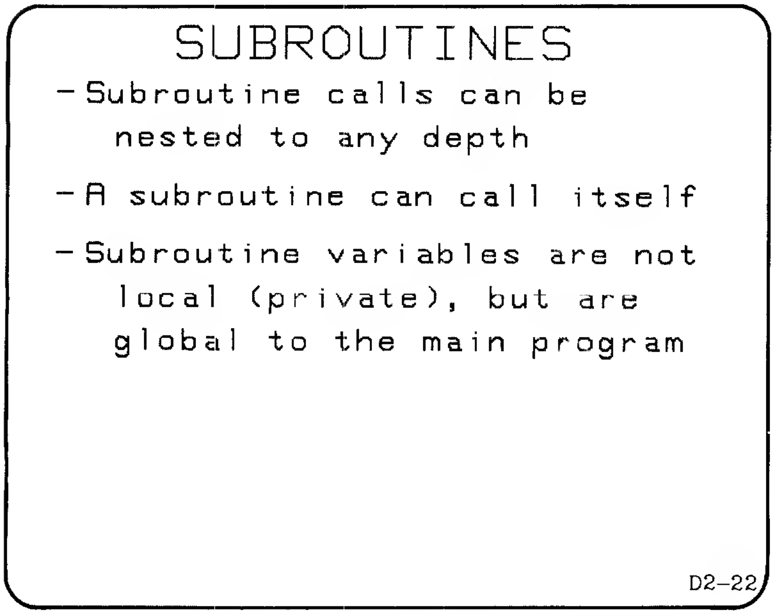


```
      .
      .
      .
100 GOSUB Count
1400 Count: FOR I=1 TO 10
1410   Sum=Sum+I
1420   NEXT I
1430 RETURN
110 Next_line: PRINT Sum
      .
      .
      .
```

Acts like inserted code

D2-21

NOTES



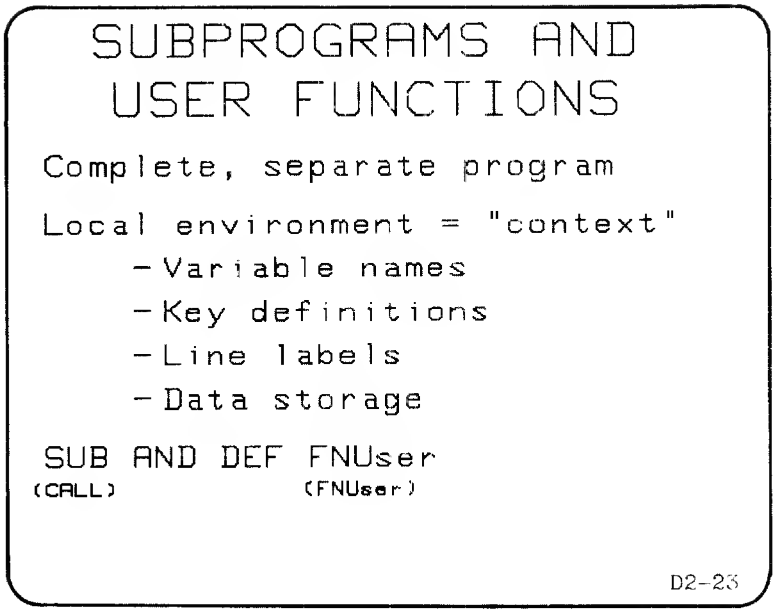
SUBROUTINES

- Subroutine calls can be nested to any depth
- A subroutine can call itself
- Subroutine variables are not local (private), but are global to the main program

D2-22

NOTES

NOTES



SUBPROGRAMS AND USER FUNCTIONS

Complete, separate program

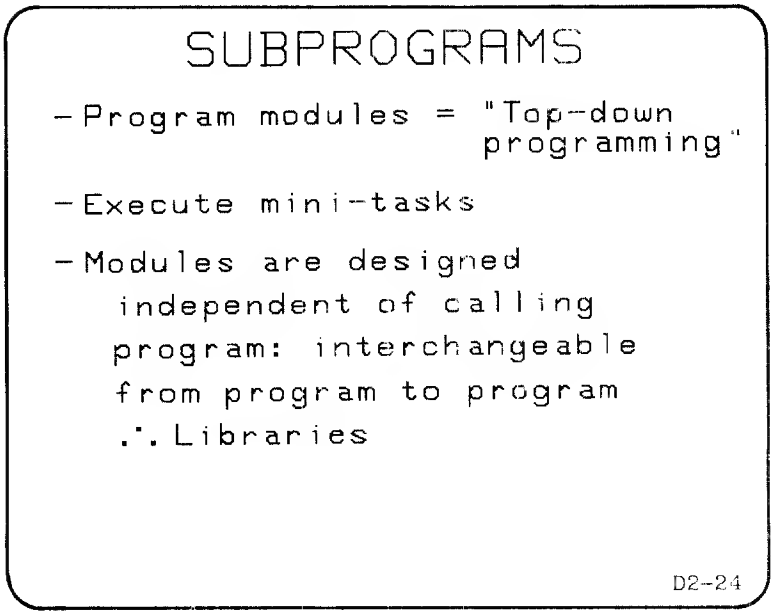
Local environment = "context"

- Variable names
- Key definitions
- Line labels
- Data storage

SUB AND DEF FNUser
(CALL) (FNUser)

D2-23

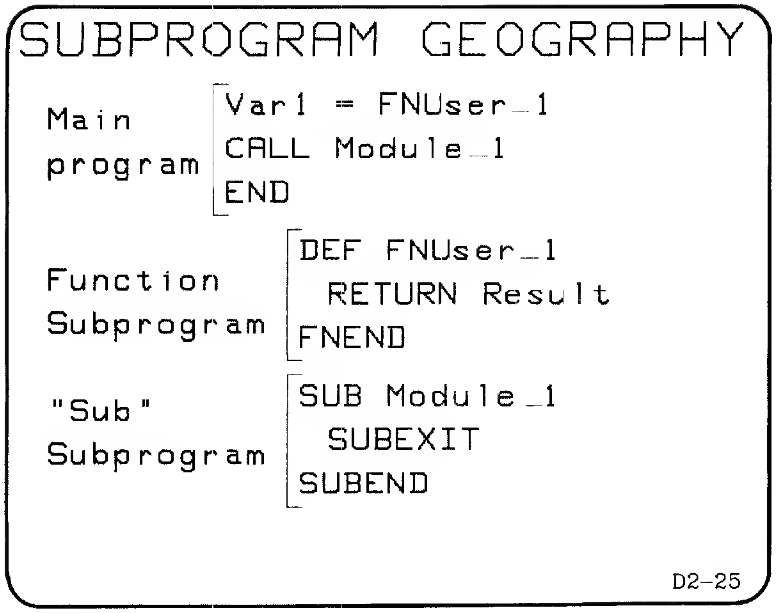
NOTES



SUBPROGRAMS

- Program modules = "Top-down programming"
- Execute mini-tasks
- Modules are designed independent of calling program: interchangeable from program to program
  ∴ Libraries

D2-24



SUBPROGRAM GEOGRAPHY

Main program

```
Var1 = FNUser_1
CALL Module_1
END
```

Function Subprogram

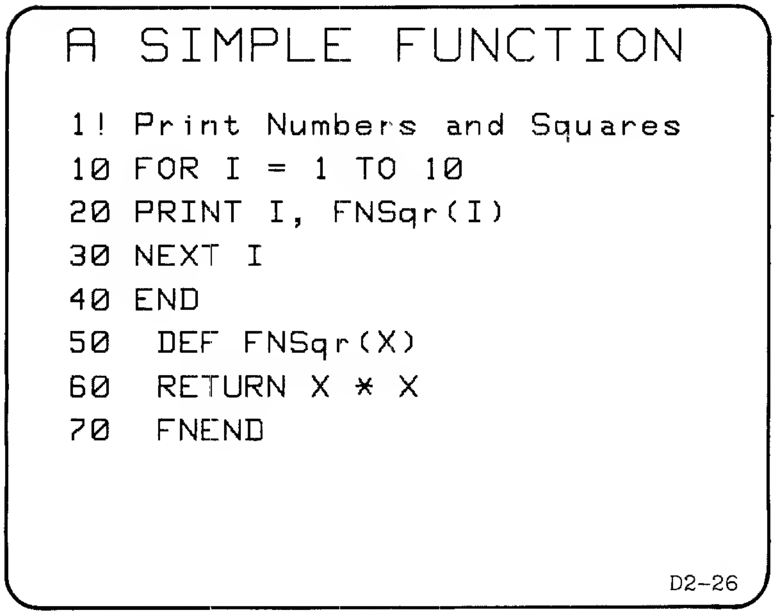
```
DEF FNUser_1
  RETURN Result
FNEND
```

"Sub" Subprogram

```
SUB Module_1
  SUBEXIT
SUBEND
```

D2-25

NOTES



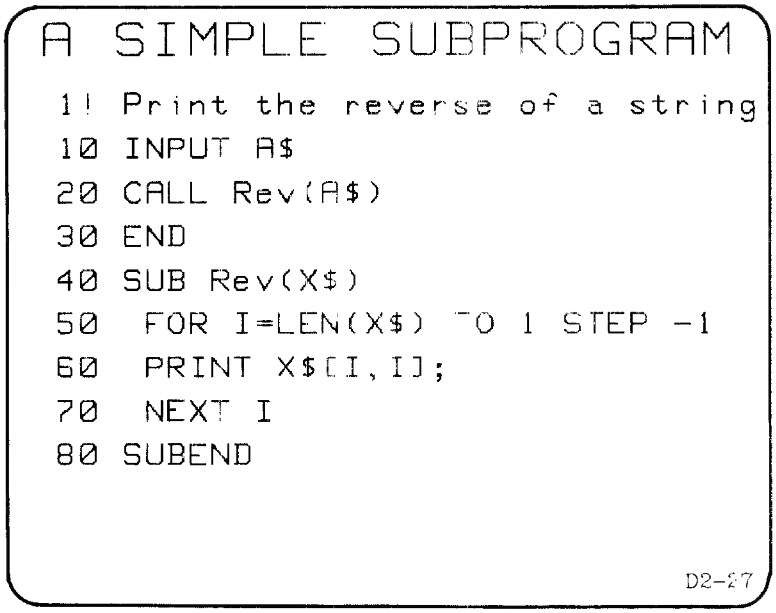
A SIMPLE FUNCTION

```
1! Print Numbers and Squares
10 FOR I = 1 TO 10
20 PRINT I, FNSqr(I)
30 NEXT I
40 END
50  DEF FNSqr(X)
60  RETURN X * X
70  FNEND
```

D2-26

NOTES

NOTES

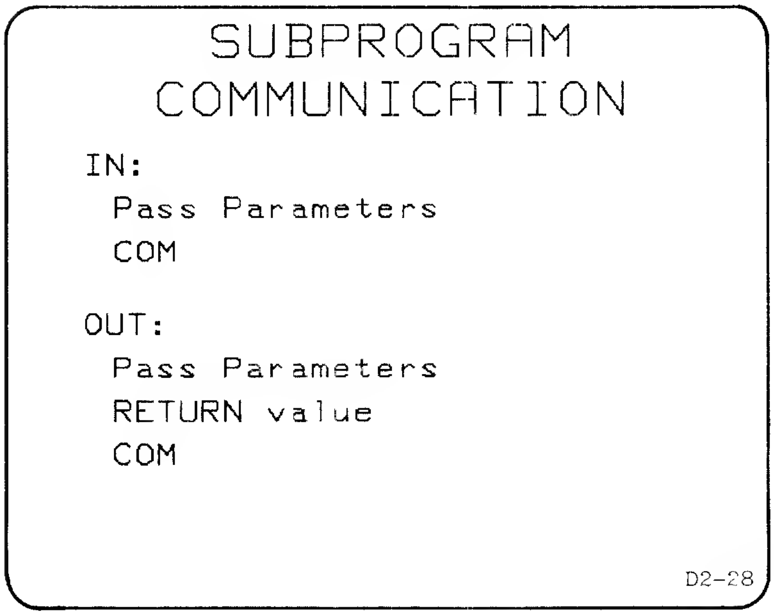


A SIMPLE SUBPROGRAM

```
1 ! Print the reverse of a string
10 INPUT A$
20 CALL Rev(A$)
30 END
40 SUB Rev(X$)
50  FOR I=LEN(X$) TO 1 STEP -1
60  PRINT X$[I,I];
70  NEXT I
80 SUBEND
```

D2-27

NOTES

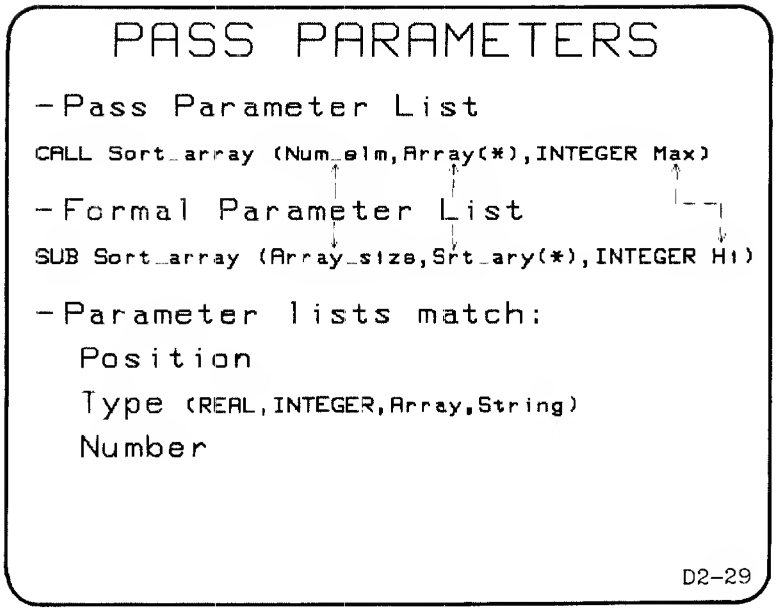


SUBPROGRAM COMMUNICATION

IN:
- Pass Parameters
- COM

OUT:
- Pass Parameters
- RETURN value
- COM

D2-28



PASS PARAMETERS

-Pass Parameter List

```
CALL Sort_array (Num_elm,Array(*),INTEGER Max)
```

-Formal Parameter List

```
SUB Sort_array (Array_size,Srt_ary(*),INTEGER Hi)
```

-Parameter lists match:

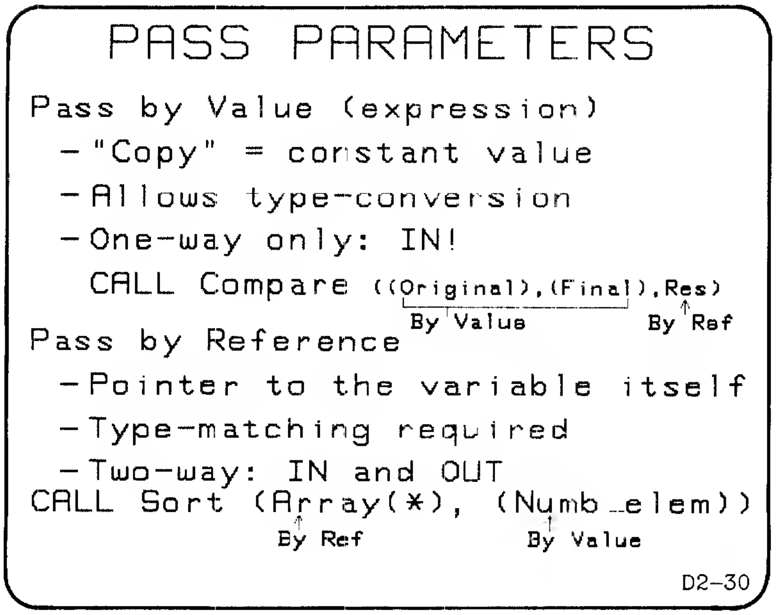
Position

Type (REAL,INTEGER,Array,String)

Number

D2-29

NOTES



PASS PARAMETERS

Pass by Value (expression)

-"Copy" = constant value

-Allows type-conversion

-One-way only: IN!

```
CALL Compare ((Original),(Final),Res)
              By Value            By Ref
```

Pass by Reference

-Pointer to the variable itself

-Type-matching required

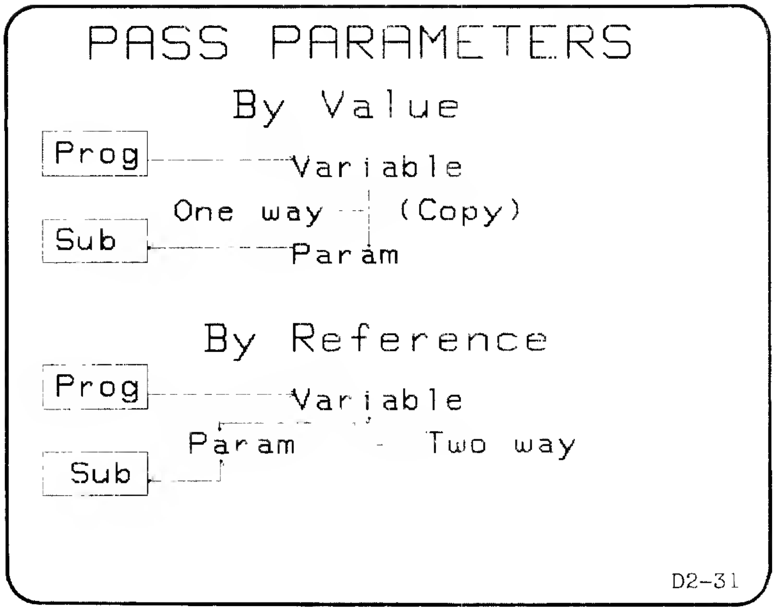
-Two-way: IN and OUT

```
CALL Sort (Array(*), (Numb_elem))
           By Ref        By Value
```

D2-30

NOTES

NOTES



PASS PARAMETERS

By Value

Prog

Variable

One way (Copy)

Sub

Param

By Reference

Prog

Variable

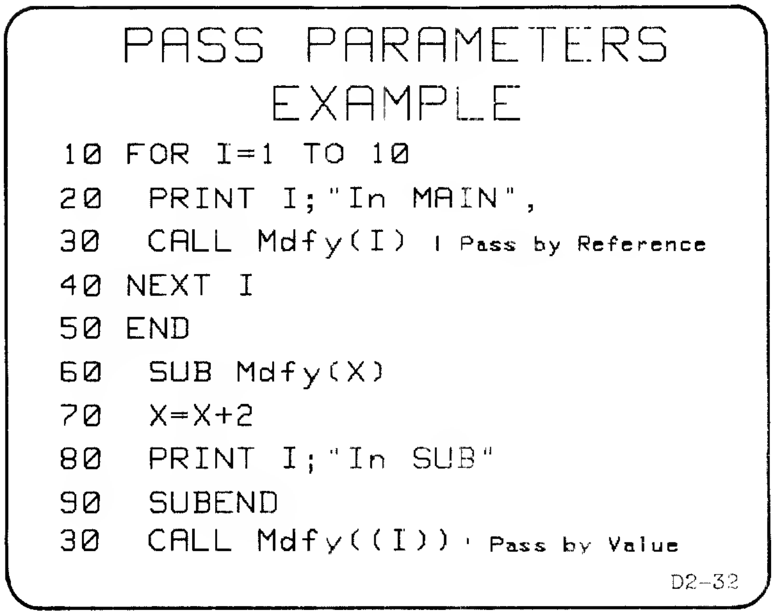
Param

Two way

Sub

D2-31

NOTES



PASS PARAMETERS EXAMPLE

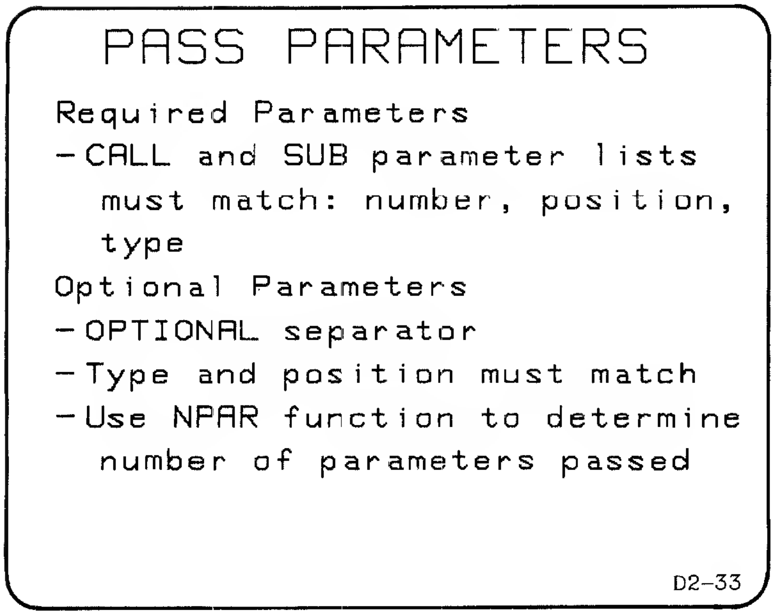
```
10 FOR I=1 TO 10
20  PRINT I;"In MAIN",
30  CALL Mdfy(I) ! Pass by Reference
40 NEXT I
50 END
60  SUB Mdfy(X)
70  X=X+2
80  PRINT I;"In SUB"
90  SUBEND
30  CALL Mdfy((I)) ! Pass by Value
```

D2-32

EXERCISE 7

GET "VAL_REF" and run the program. See if you can figure out how the program looks by just studying its output. Can you explain the last block of output? What happened to I?

LIST the program and see if it looks the way you predicted. Check the pass-by-value and pass-by-reference function calls. Look at the two functions and analyze how they affect their pass parameters.



PASS PARAMETERS

Required Parameters

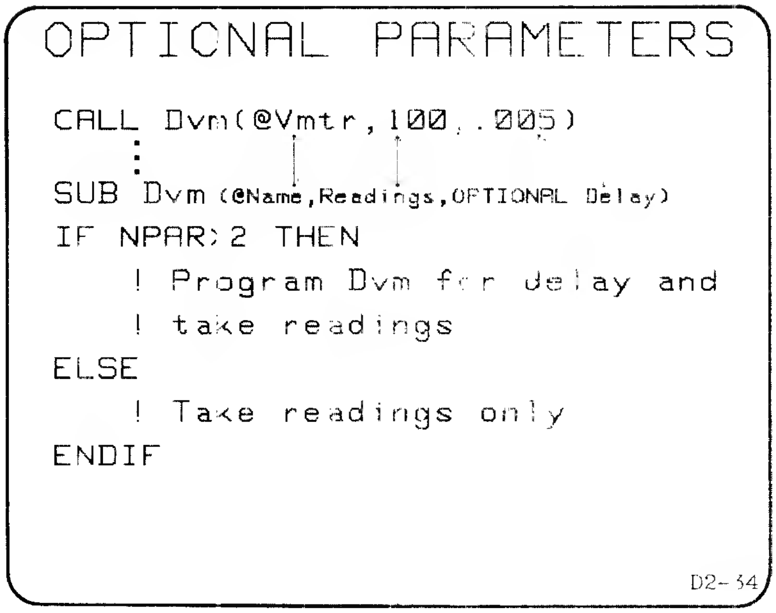
- CALL and SUB parameter lists must match: number, position, type

Optional Parameters

- OPTIONAL separator
- Type and position must match
- Use NPAR function to determine number of parameters passed

D2-33

NOTES



OPTIONAL PARAMETERS

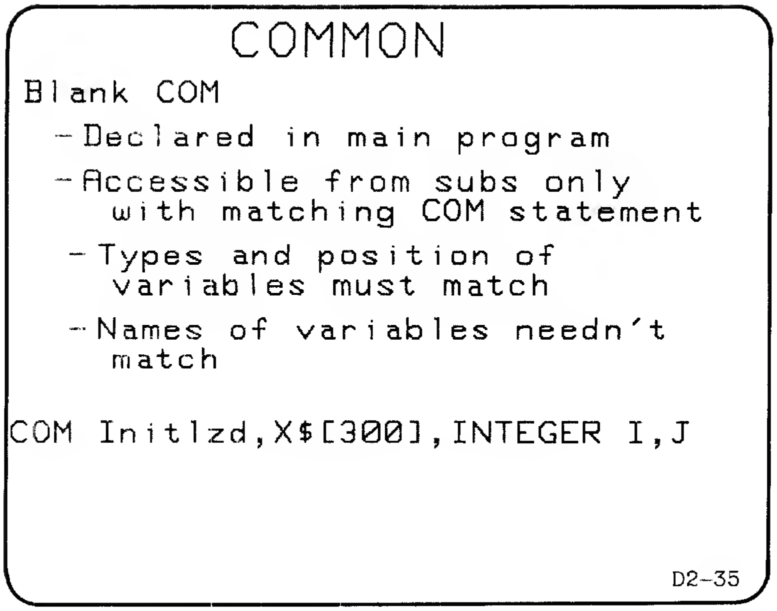
```
CALL Dvm(@Vmtr,100,.005)
    :
SUB Dvm (@Name,Readings,OPTIONAL Delay)
IF NPAR>2 THEN
    ! Program Dvm for delay and
    ! take readings
ELSE
    ! Take readings only
ENDIF
```

D2-34

EXERCISE 8

GET "NPAR" and try running the program. See if you can analyze the problem. After you have the types matched, re-run the program. Be sure you understand the flow of the program before moving on to the next slide. (In the first call, C is an "optional" parameter. In the second call, the optional parameter was not passed, and the subprogram executed a different statement block.)

Which construct might be more appropriate for multiple optional parameters than the IF/THEN/ELSE construct?



COMMON

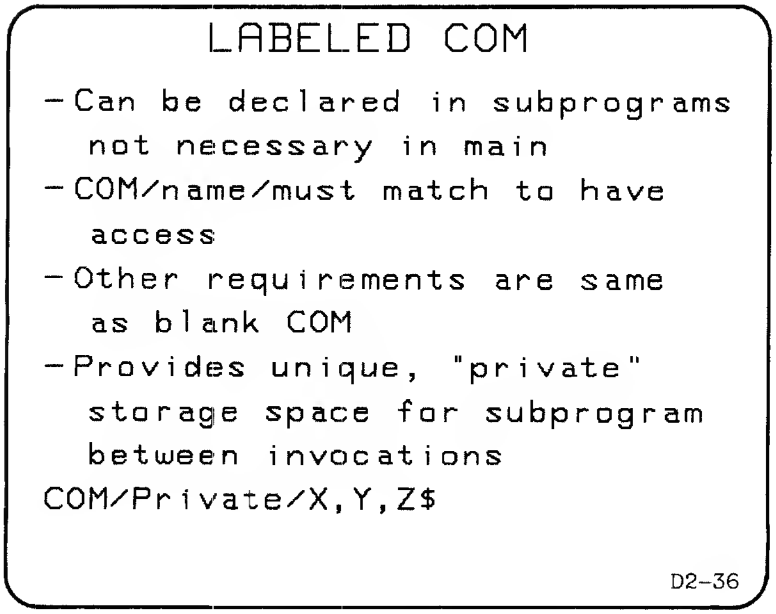
Blank COM

- Declared in main program
- Accessible from subs only with matching COM statement
- Types and position of variables must match
- Names of variables needn't match

```
COM Initlzd,X$[300],INTEGER I,J
```

D2-35

NOTES



LABELED COM

- Can be declared in subprograms not necessary in main
- COM/name/must match to have access
- Other requirements are same as blank COM
- Provides unique, "private" storage space for subprogram between invocations

```
COM/Private/X,Y,Z$
```

D2-36

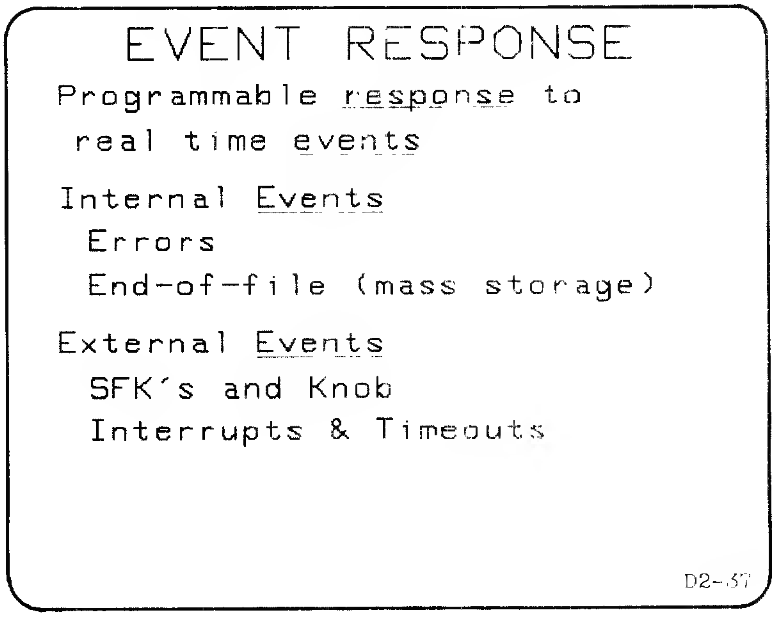
NOTES

EXERCISE 9

GET "LABEL_COM" and run the program. Note what happened to variables A,B, and C across the main program and the two subprograms. What happened to A,B, and C after calling the first subprogram? Was the main program able to access variables L,M, and N of the labeled common? (If it could, the values assigned to L,M, and N in the first subprogram would be printed by main after the call.)

Was the second subprogram able to access all variables?

NOTES



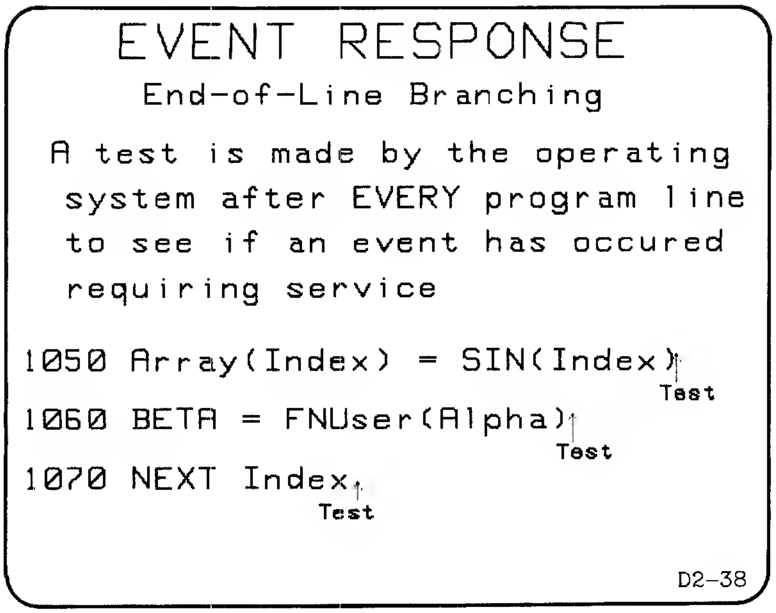
EVENT RESPONSE

Programmable response to real time events

Internal Events
- Errors
- End-of-file (mass storage)

External Events
- SFK's and Knob
- Interrupts & Timeouts

D2-57



EVENT RESPONSE

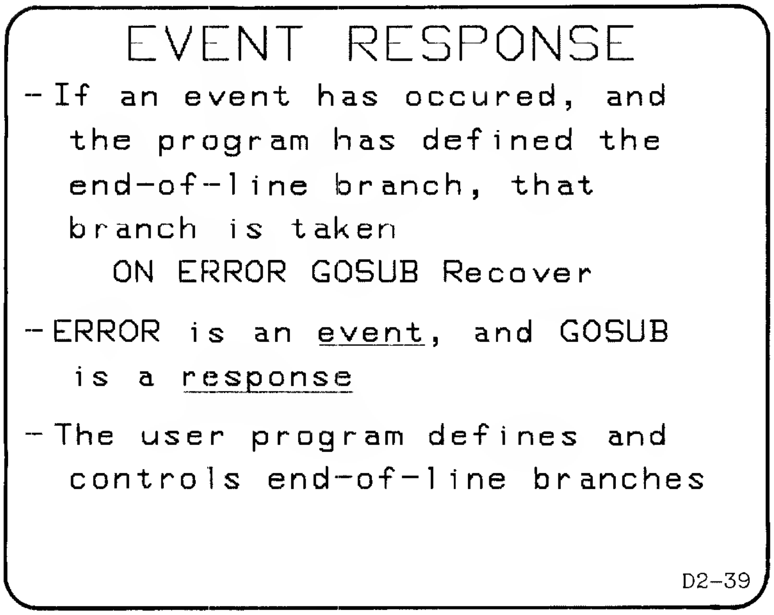
End-of-Line Branching

A test is made by the operating system after EVERY program line to see if an event has occured requiring service

```
1050 Array(Index) = SIN(Index)↑
                              Test
1060 BETA = FNUser(Alpha)↑
                         Test
1070 NEXT Index↑
                Test
```

D2-38

NOTES



EVENT RESPONSE

- If an event has occured, and the program has defined the end-of-line branch, that branch is taken

  ON ERROR GOSUB Recover

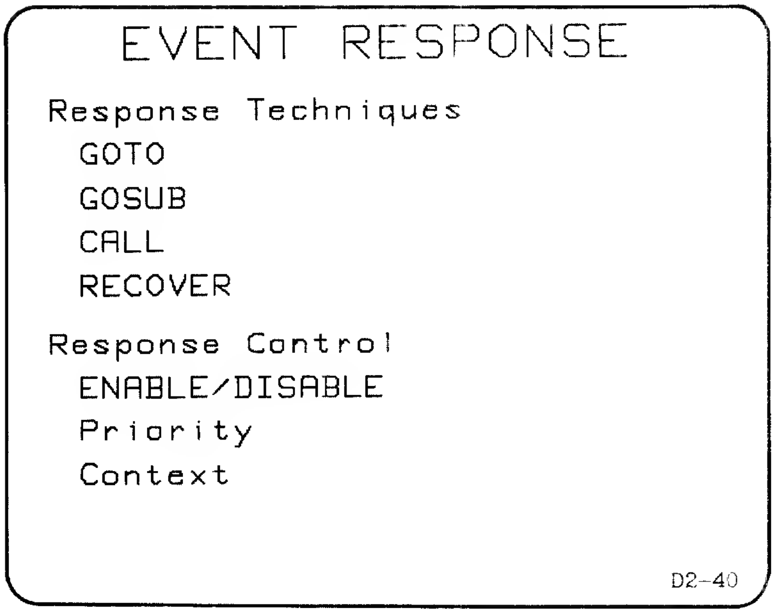
- ERROR is an <u>event</u>, and GOSUB is a <u>response</u>

- The user program defines and controls end-of-line branches

D2-39

NOTES

NOTES



EVENT RESPONSE

Response Techniques

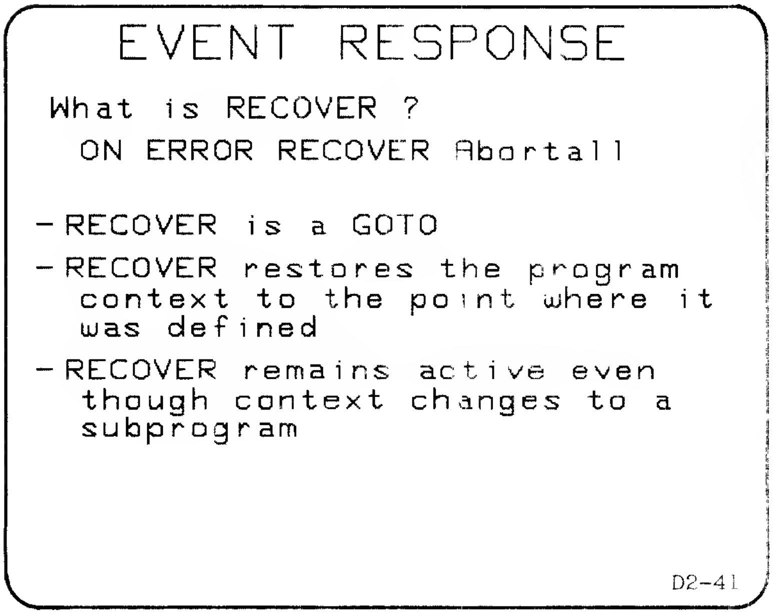
- GOTO
- GOSUB
- CALL
- RECOVER

Response Control

- ENABLE/DISABLE
- Priority
- Context

D2-40

NOTES



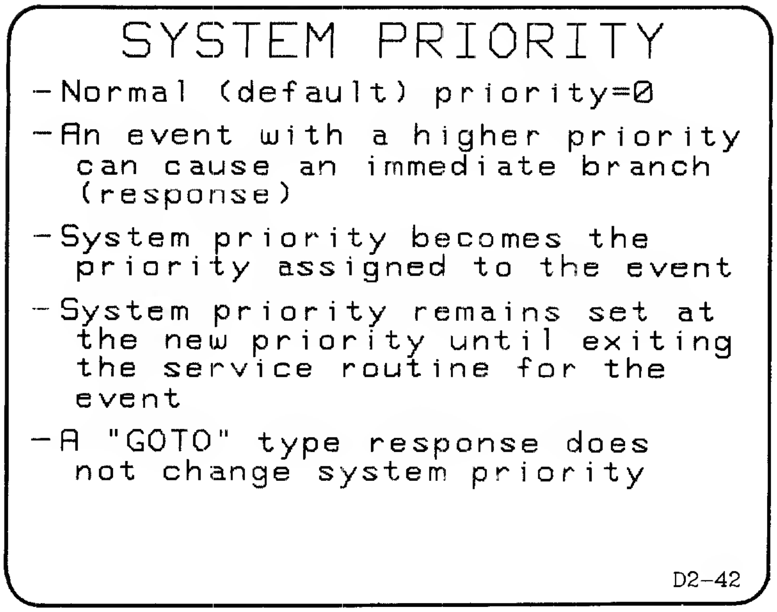
EVENT RESPONSE

What is RECOVER ?

ON ERROR RECOVER Abortall

- RECOVER is a GOTO
- RECOVER restores the program context to the point where it was defined
- RECOVER remains active even though context changes to a subprogram

D2-41

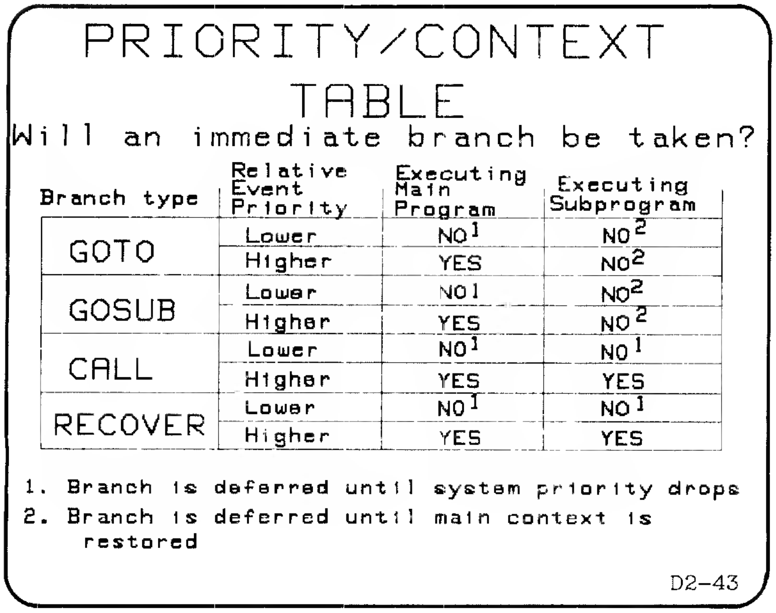


SYSTEM PRIORITY

- Normal (default) priority=0
- An event with a higher priority can cause an immediate branch (response)
- System priority becomes the priority assigned to the event
- System priority remains set at the new priority until exiting the service routine for the event
- A "GOTO" type response does not change system priority

D2-42

NOTES



PRIORITY/CONTEXT TABLE

Will an immediate branch be taken?

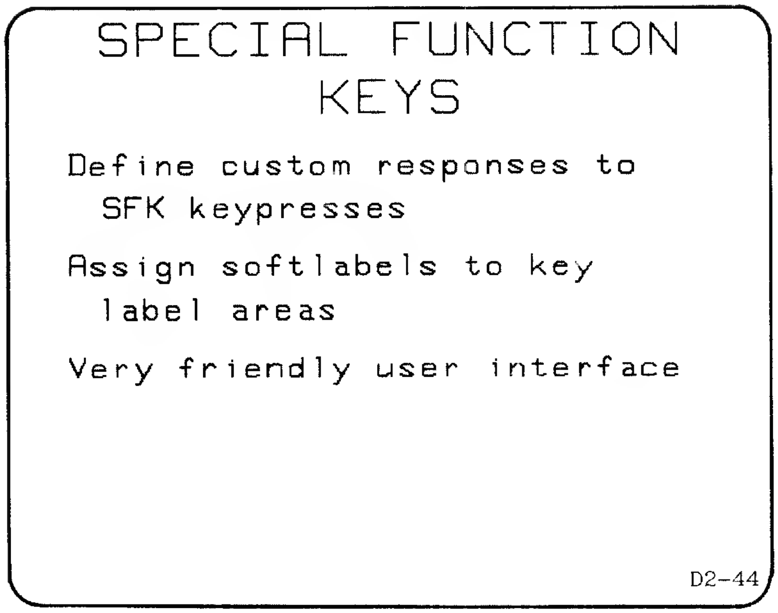
Branch type	Relative Event Priority	Executing Main Program	Executing Subprogram
GOTO	Lower	NO[1]	NO[2]
	Higher	YES	NO[2]
GOSUB	Lower	NO[1]	NO[2]
	Higher	YES	NO[2]
CALL	Lower	NO[1]	NO[1]
	Higher	YES	YES
RECOVER	Lower	NO[1]	NO[1]
	Higher	YES	YES

1. Branch is deferred until system priority drops
2. Branch is deferred until main context is restored

D2-43

NOTES

NOTES



SPECIAL FUNCTION KEYS

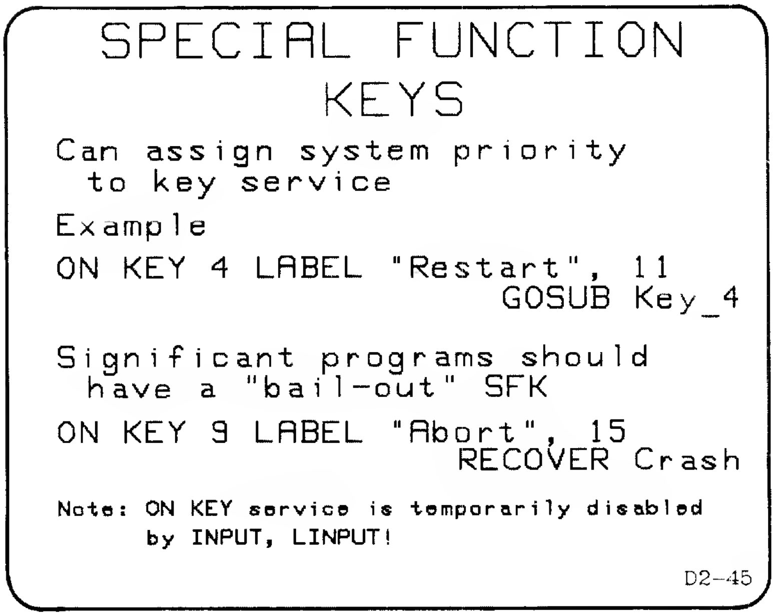
Define custom responses to SFK keypresses

Assign softlabels to key label areas

Very friendly user interface

D2-44

NOTES



SPECIAL FUNCTION KEYS

Can assign system priority to key service

Example

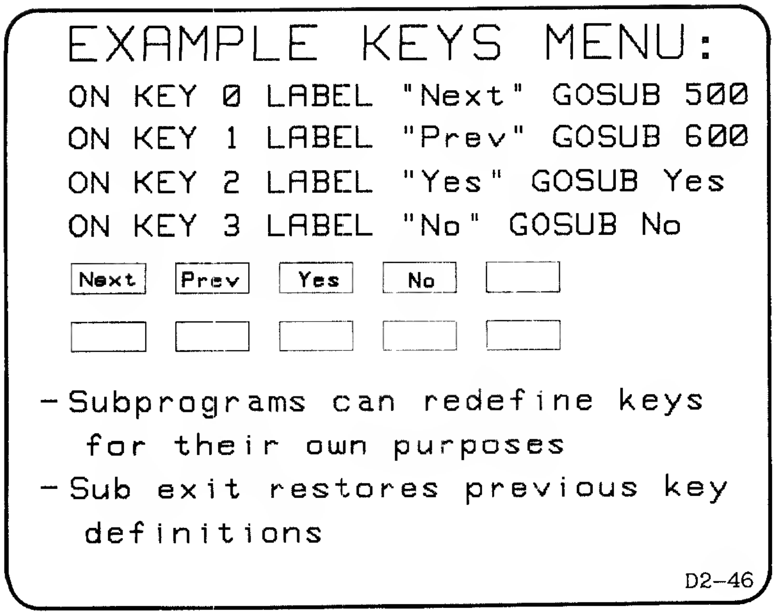
```
ON KEY 4 LABEL "Restart", 11
                         GOSUB Key_4
```

Significant programs should have a "bail-out" SFK

```
ON KEY 9 LABEL "Abort", 15
                       RECOVER Crash
```

Note: ON KEY service is temporarily disabled by INPUT, LINPUT!

D2-45



EXAMPLE KEYS MENU:

```
ON KEY 0 LABEL "Next" GOSUB 500
ON KEY 1 LABEL "Prev" GOSUB 600
ON KEY 2 LABEL "Yes" GOSUB Yes
ON KEY 3 LABEL "No" GOSUB No
```

Next
Prev
Yes
No

- Subprograms can redefine keys for their own purposes
- Sub exit restores previous key definitions

D2-46

EXERCISE 10

GET "KEYS1" and list the program. Note how the special keys are set up, labels defined, and priorities established. Note especially what happens in Sub3: a key is re-defined with a new priority, label, and response. Run the program and try various combinations of keys, noting which keypress get immediate response, and which ones are deferred. Try pressing a key twice to see if it's service routine is executed twice (watch the counter).

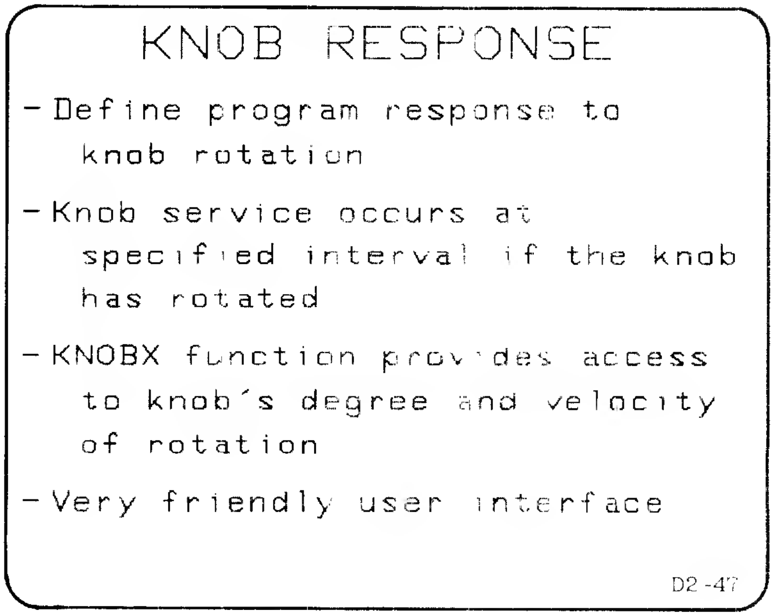
EXERCISE 11

GET "PRIORITIES" and list the program. Note the key redefinition in Pri10. Will pressing K4 while Pri10 is executing cause an immediate branch to Pri 14?

Run the program. Press K0, K2, and K4 in rapid succession. Can you explain why K2 caused an immediate response while K4 did not? Why was the Priority 14 subprogram executed before returning back to the Priority 5 subprogram?

Try pressing the K5 "GOSUB" key from the main program. Now try pressing it from any of the subprograms. Why is K5 service deferred even though it has the highest priority? Can any of the subprograms interrupt the priority 15 subroutine service?

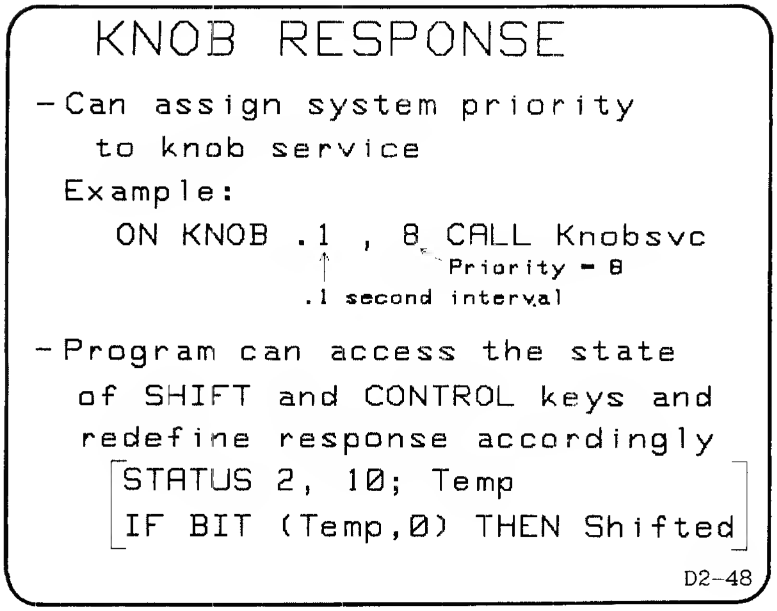
NOTES



KNOB RESPONSE

- Define program response to knob rotation
- Knob service occurs at specified interval if the knob has rotated
- KNOBX function provides access to knob's degree and velocity of rotation
- Very friendly user interface

D2-47



KNOB RESPONSE

- Can assign system priority to knob service

  Example:

```
ON KNOB .1 , 8 CALL Knobsvc
         ↑          Priority = 8
  .1 second interval
```

- Program can access the state of SHIFT and CONTROL keys and redefine response accordingly

```
STATUS 2, 10; Temp
IF BIT (Temp,0) THEN Shifted
```

D2-48

NOTES

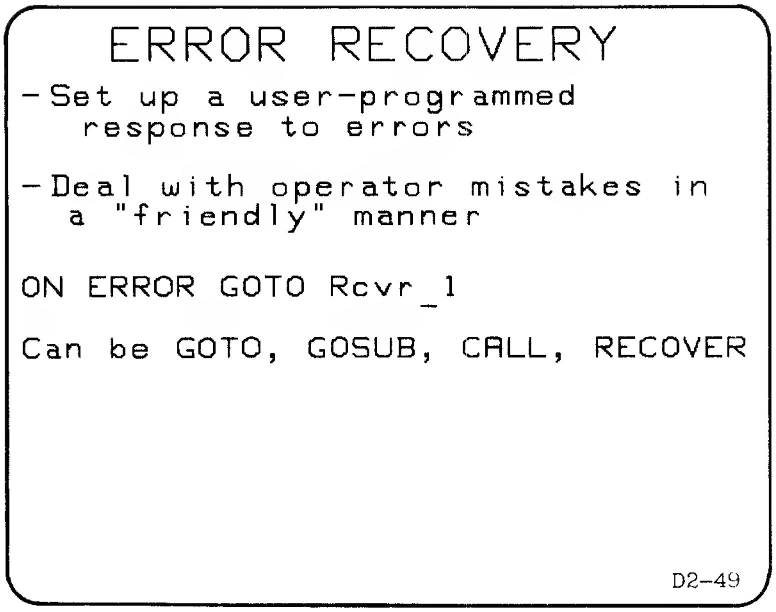
EXERCISE 12

Write a program that responds to knob rotation and executes BEEP with varying frequencies depending on the degree of rotation of the knob.

Hints:

1. Use absolute value of KNOBX.
2. You may need to multiply the result of #1 above by 10 or so to obtain suitable values for BEEP frequencies.
3. Use the reference manual to look up statement syntaxes, if necessary.

NOTES



ERROR RECOVERY

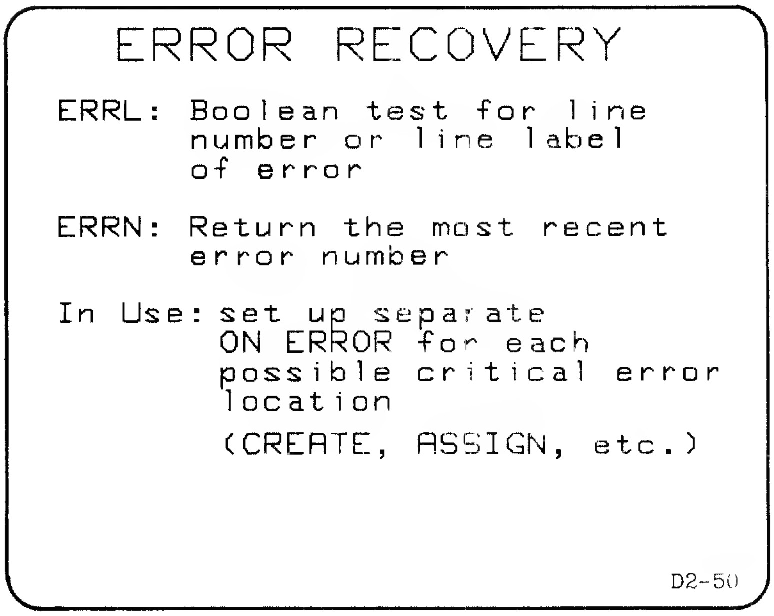
- Set up a user-programmed response to errors
- Deal with operator mistakes in a "friendly" manner

ON ERROR GOTO Rcvr_1

Can be GOTO, GOSUB, CALL, RECOVER

D2-49

NOTES



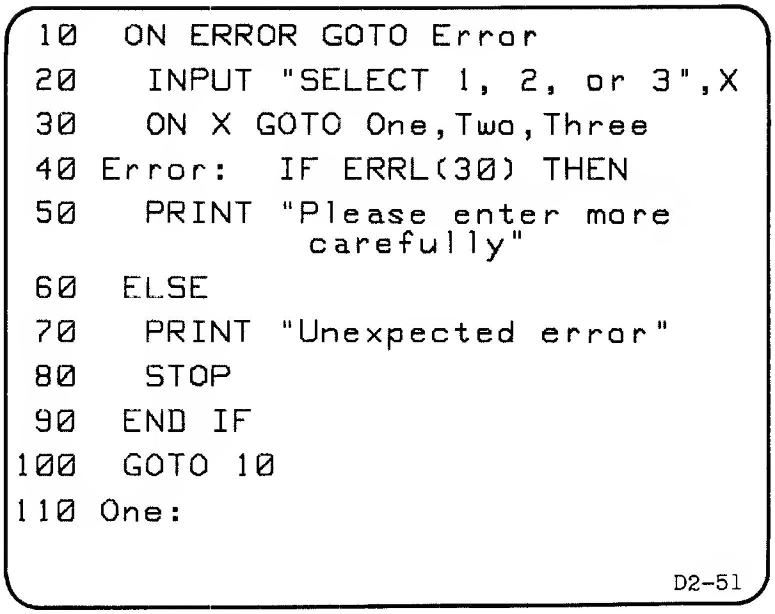
ERROR RECOVERY

ERRL: Boolean test for line number or line label of error

ERRN: Return the most recent error number

In Use: set up separate ON ERROR for each possible critical error location
(CREATE, ASSIGN, etc.)

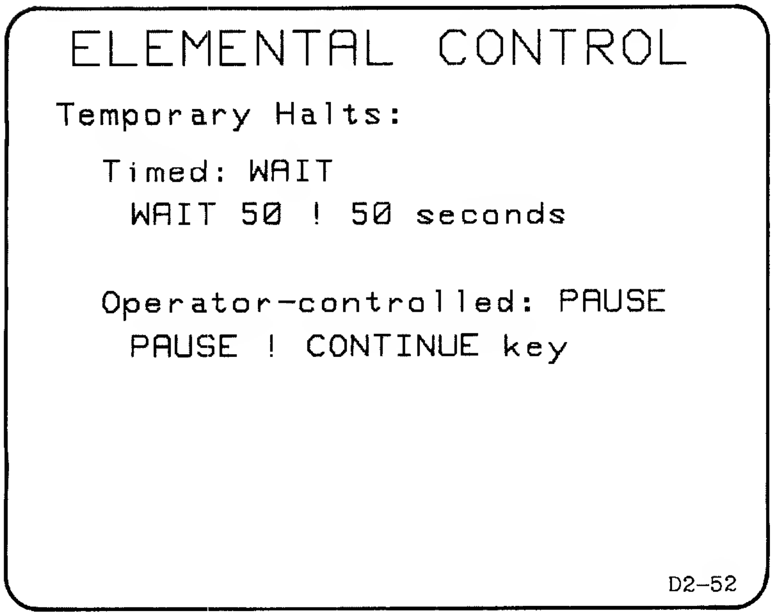
D2-50



```
 10  ON ERROR GOTO Error
 20   INPUT "SELECT 1, 2, or 3",X
 30   ON X GOTO One,Two,Three
 40 Error:  IF ERRL(30) THEN
 50   PRINT "Please enter more
               carefully"
 60  ELSE
 70   PRINT "Unexpected error"
 80   STOP
 90  END IF
100  GOTO 10
110 One:
```

D2-51

NOTES



ELEMENTAL CONTROL

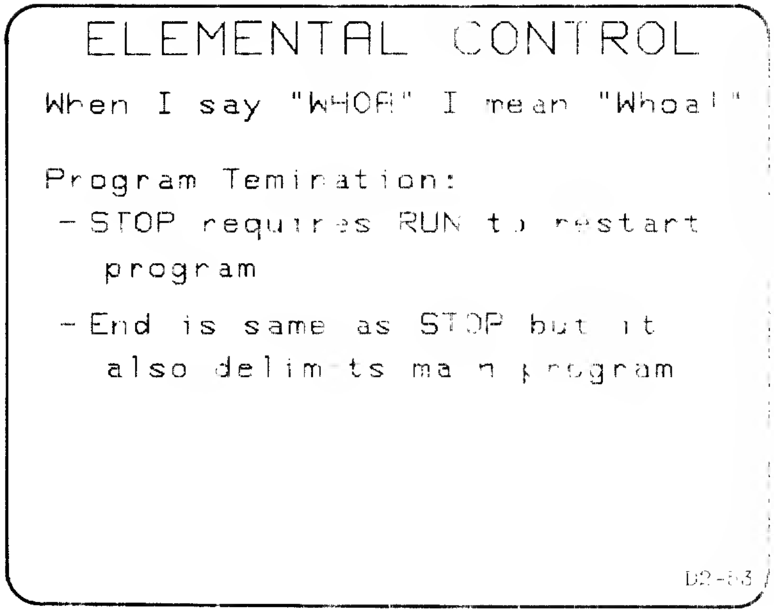
Temporary Halts:

```
  Timed: WAIT
   WAIT 50 ! 50 seconds

  Operator-controlled: PAUSE
   PAUSE ! CONTINUE key
```

D2-52

NOTES

NOTES



ELEMENTAL CONTROL

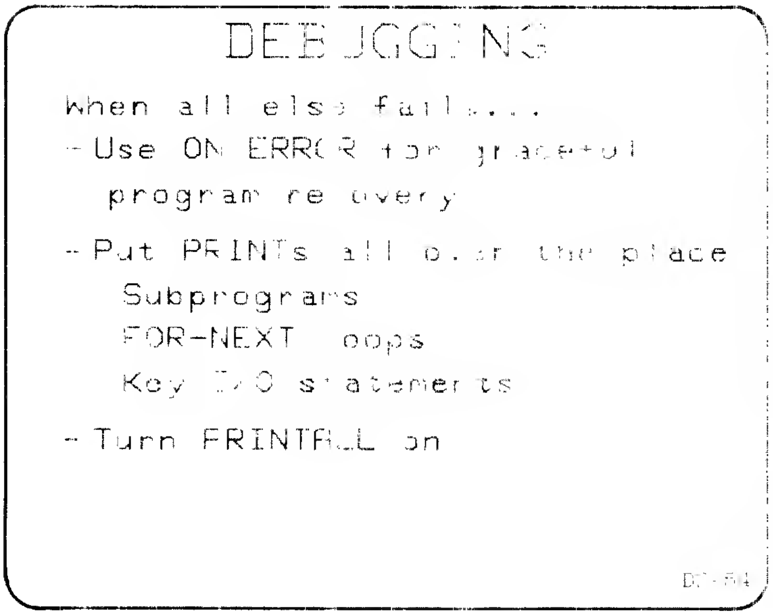
When I say "WHOA" I mean "Whoa!"

Program Temination:

- STOP requires RUN to restart program
- End is same as STOP but it also delimits main program

D2-53

NOTES

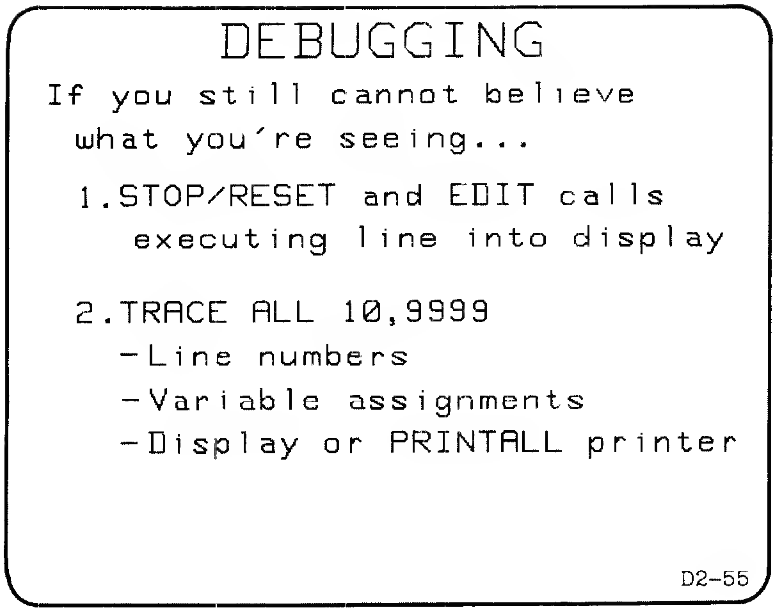


DEBUGGING

When all else fails....

- Use ON ERROR for graceful program recovery
- Put PRINTs all over the place
  - Subprograms
  - FOR-NEXT loops
  - Key I/O statements
- Turn PRINTALL on

D2-54



DEBUGGING

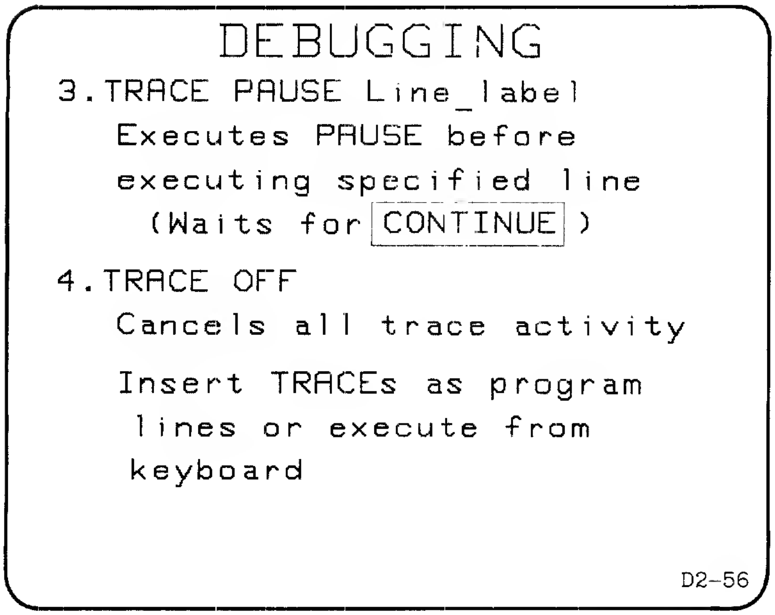
If you still cannot believe what you're seeing...

1. STOP/RESET and EDIT calls executing line into display

2. TRACE ALL 10,9999
   - Line numbers
   - Variable assignments
   - Display or PRINTALL printer

D2-55

NOTES



DEBUGGING

3. TRACE PAUSE Line_label
   Executes PAUSE before executing specified line
   (Waits for CONTINUE)

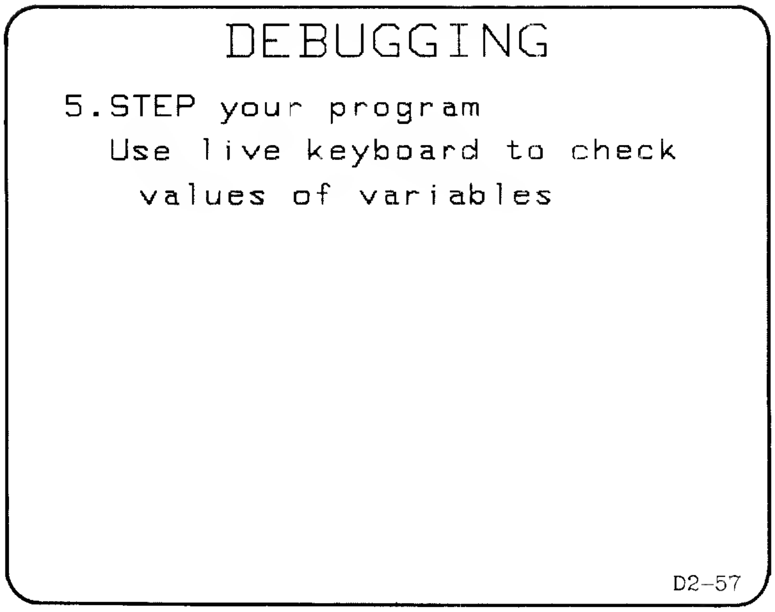
4. TRACE OFF
   Cancels all trace activity

   Insert TRACEs as program lines or execute from keyboard

D2-56

NOTES

NOTES

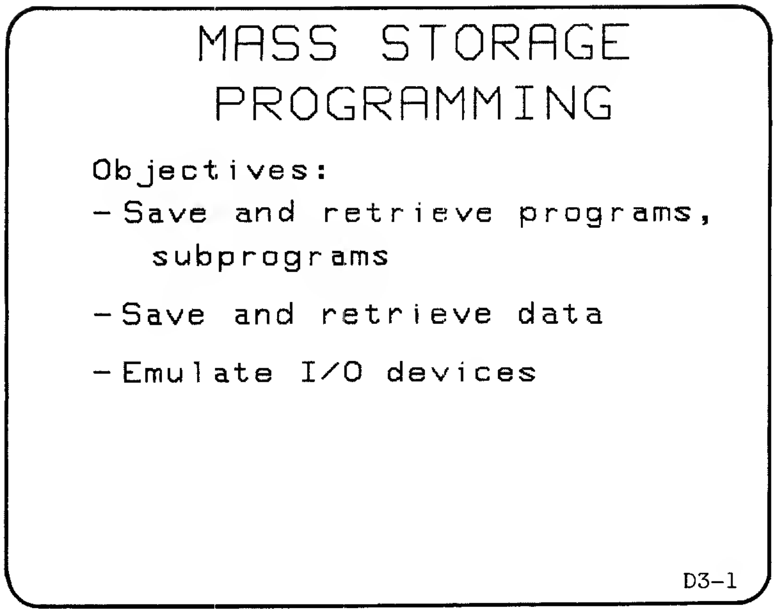


DEBUGGING

5. STEP your program

Use live keyboard to check values of variables

D2-57



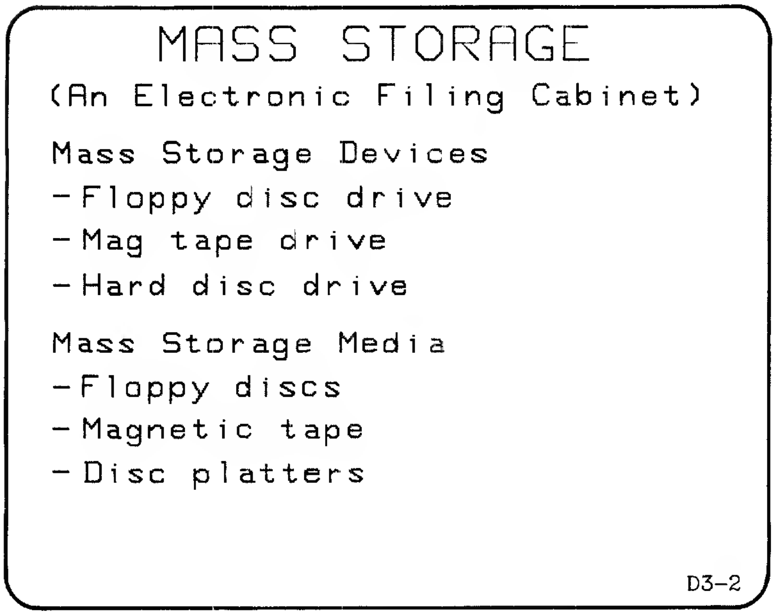
MASS STORAGE PROGRAMMING

Objectives:

- Save and retrieve programs, subprograms
- Save and retrieve data
- Emulate I/O devices

D3-1

NOTES



MASS STORAGE

(An Electronic Filing Cabinet)

Mass Storage Devices

- Floppy disc drive
- Mag tape drive
- Hard disc drive

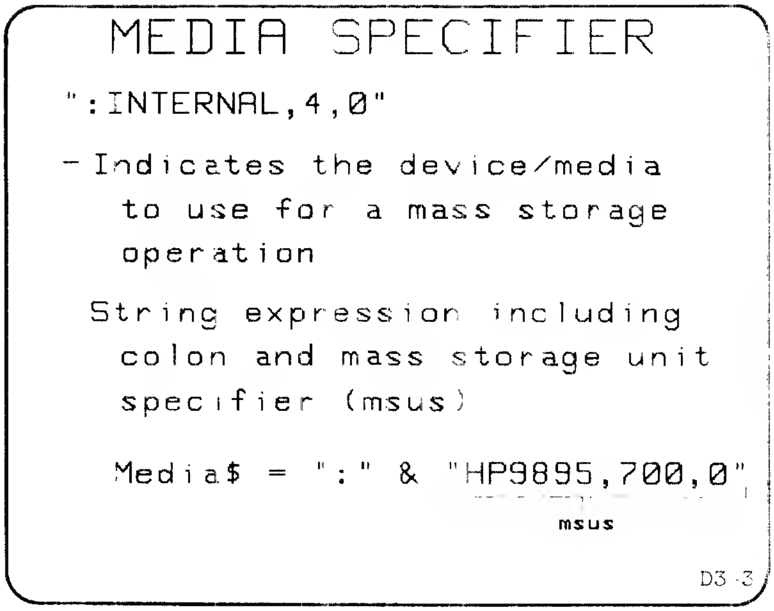
Mass Storage Media

- Floppy discs
- Magnetic tape
- Disc platters

D3-2

NOTES

NOTES



MEDIA SPECIFIER

":INTERNAL,4,0"

- Indicates the device/media to use for a mass storage operation

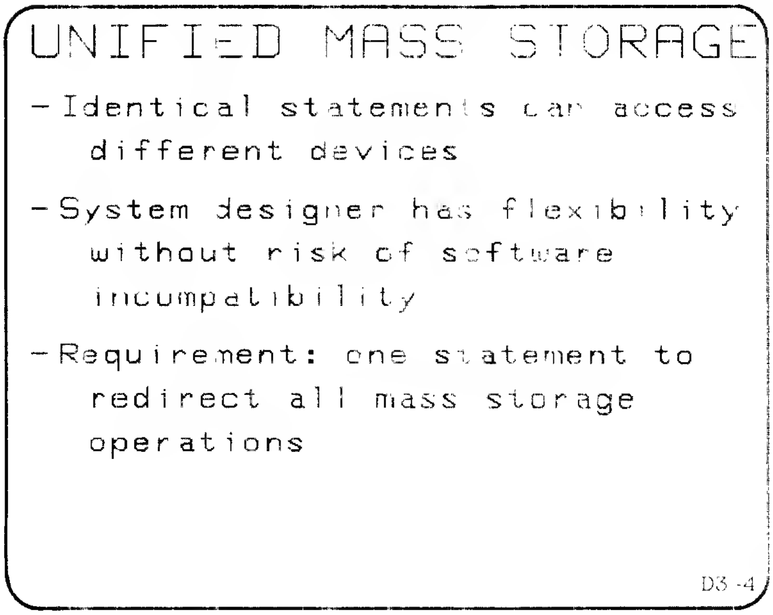
String expression including colon and mass storage unit specifier (msus)

Media$ = ":" & "HP9895,700,0"

msus

D3-3

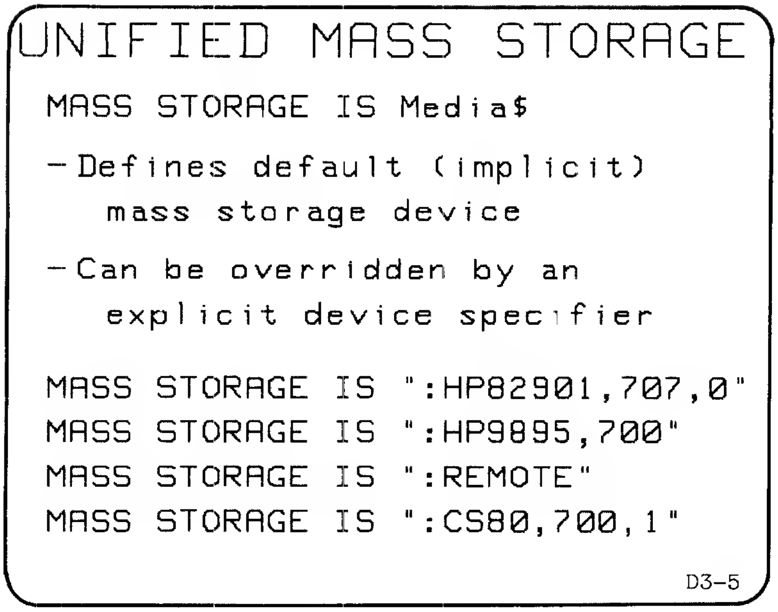
NOTES



UNIFIED MASS STORAGE

- Identical statements can access different devices
- System designer has flexibility without risk of software incompatibility
- Requirement: one statement to redirect all mass storage operations

D3-4



UNIFIED MASS STORAGE

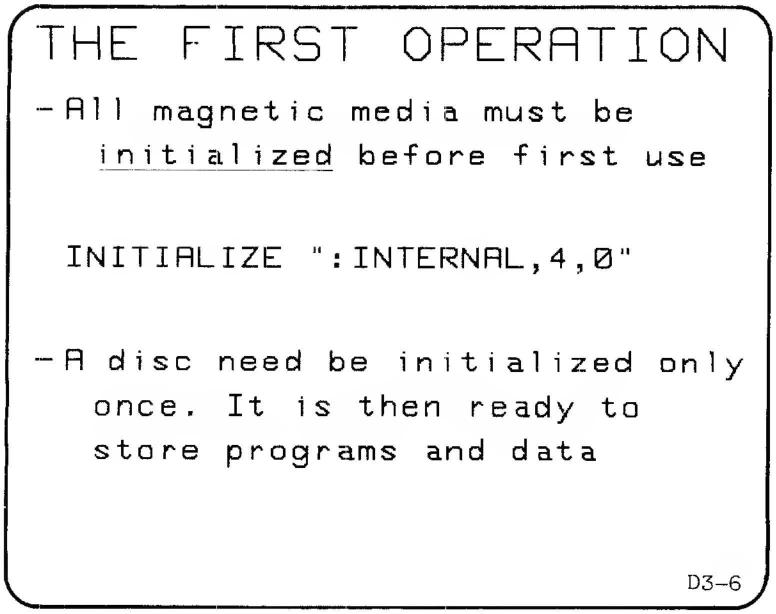
MASS STORAGE IS Media$

- Defines default (implicit) mass storage device
- Can be overridden by an explicit device specifier

```
MASS STORAGE IS ":HP82901,707,0"
MASS STORAGE IS ":HP9895,700"
MASS STORAGE IS ":REMOTE"
MASS STORAGE IS ":CS80,700,1"
```

D3-5

NOTES



THE FIRST OPERATION

- All magnetic media must be initialized before first use

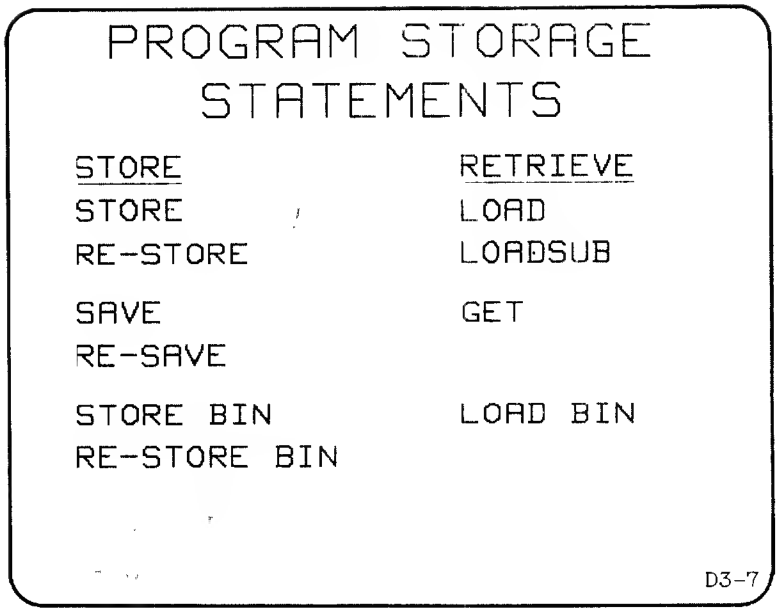
```
INITIALIZE ":INTERNAL,4,0"
```

- A disc need be initialized only once. It is then ready to store programs and data

D3-6

NOTES

NOTES

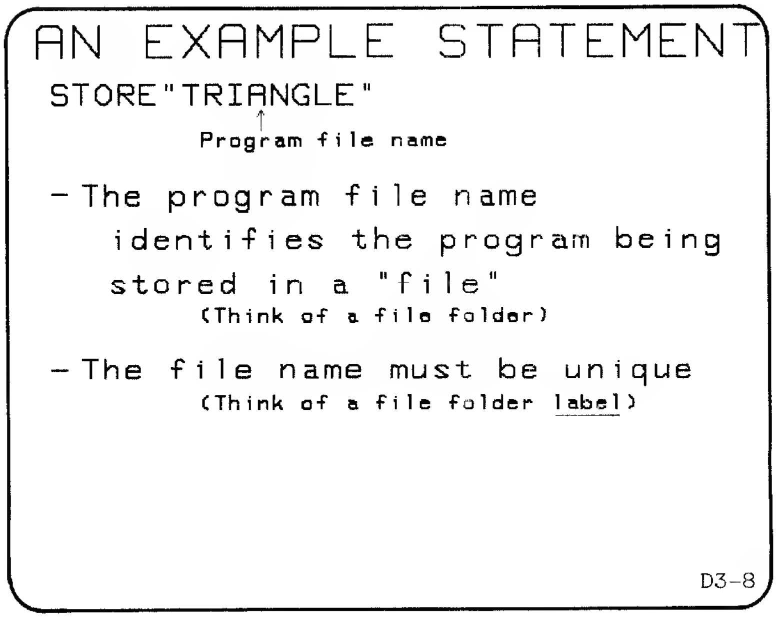


PROGRAM STORAGE STATEMENTS

STORE	RETRIEVE
STORE	LOAD
RE-STORE	LOADSUB
SAVE	GET
RE-SAVE	
STORE BIN	LOAD BIN
RE-STORE BIN	

D3-7

NOTES



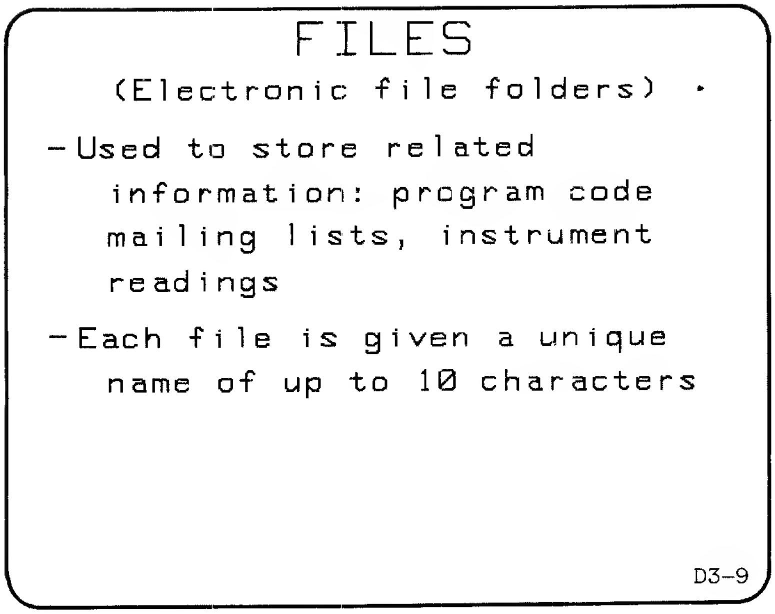
AN EXAMPLE STATEMENT

STORE"TRIANGLE"

Program file name

- The program file name identifies the program being stored in a "file"
  (Think of a file folder)
- The file name must be unique
  (Think of a file folder label)

D3-8



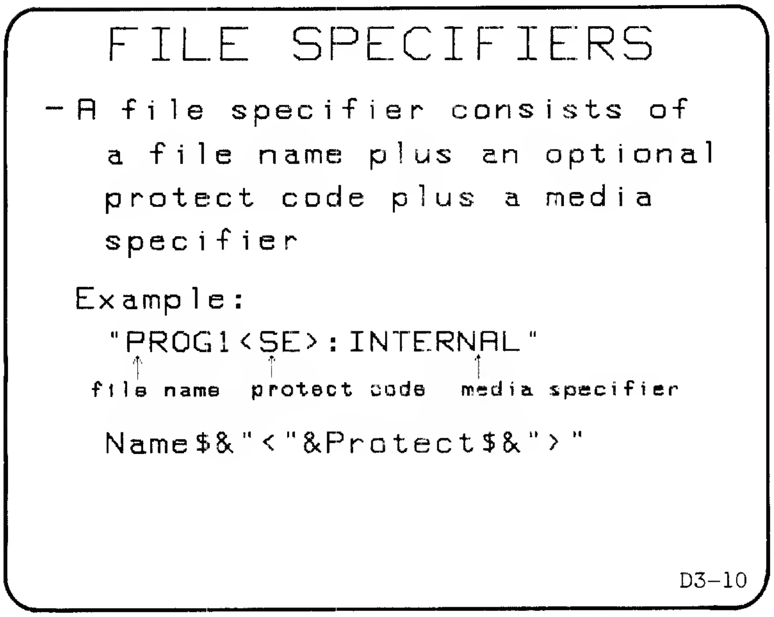
FILES

(Electronic file folders)

- Used to store related information: program code mailing lists, instrument readings
- Each file is given a unique name of up to 10 characters

D3-9

NOTES



FILE SPECIFIERS

- A file specifier consists of a file name plus an optional protect code plus a media specifier

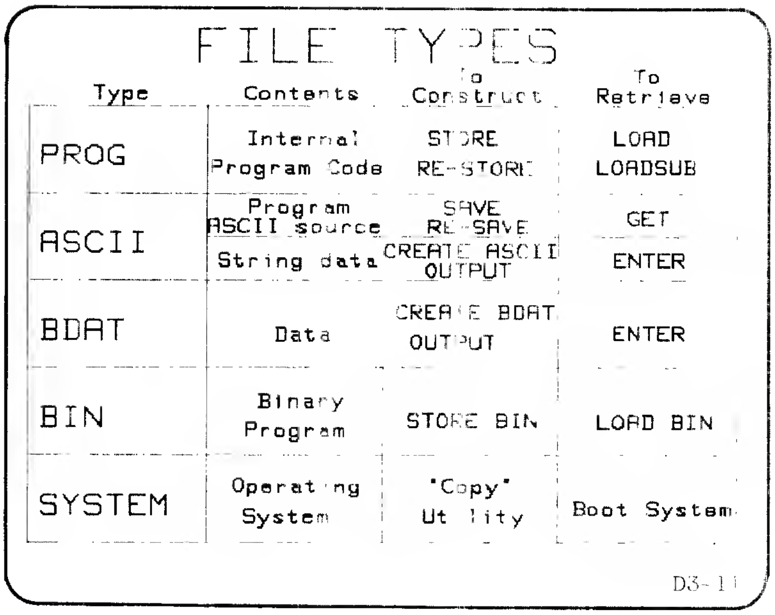
Example:

```
"PROG1<SE>:INTERNAL"
 ↑      ↑       ↑
file name   protect code   media specifier

Name$&"<"&Protect$&">"
```

D3-10

NOTES

NOTES

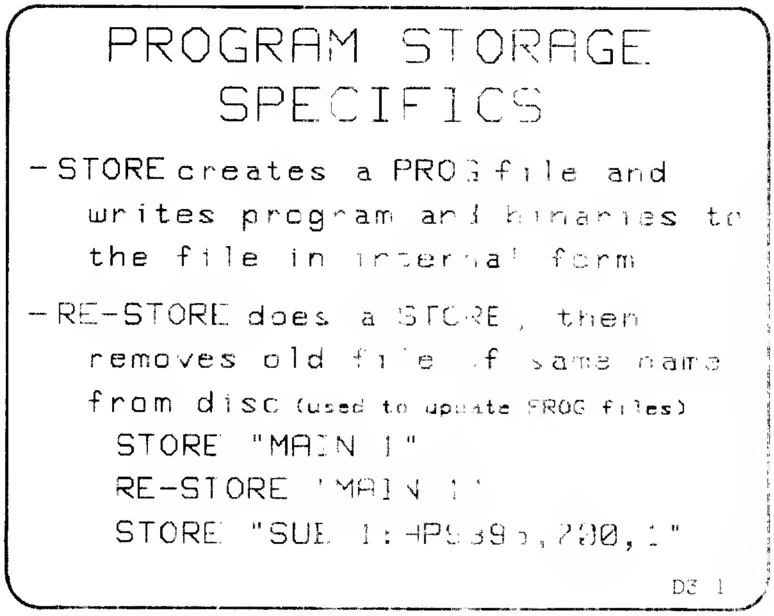


FILE TYPES

Type	Contents	To Construct	To Retrieve
PROG	Internal Program Code	STORE RE-STORE	LOAD LOADSUB
ASCII	Program ASCII source	SAVE RE-SAVE	GET
	String data	CREATE ASCII OUTPUT	ENTER
BDAT	Data	CREATE BDAT OUTPUT	ENTER
BIN	Binary Program	STORE BIN	LOAD BIN
SYSTEM	Operating System	"Copy" Utility	Boot System

D3-11

NOTES

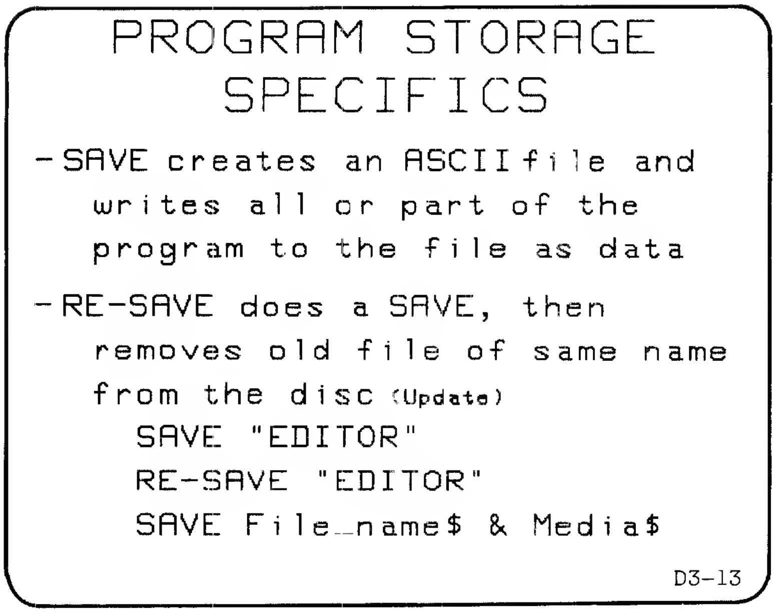


PROGRAM STORAGE SPECIFICS

- STORE creates a PROG file and writes program and binaries to the file in internal form
- RE-STORE does a STORE, then removes old file of same name from disc (used to update PROG files)

```
STORE "MAIN 1"
RE-STORE "MAIN 1"
STORE "SUB 1:HP9895,700,1"
```

D3-1



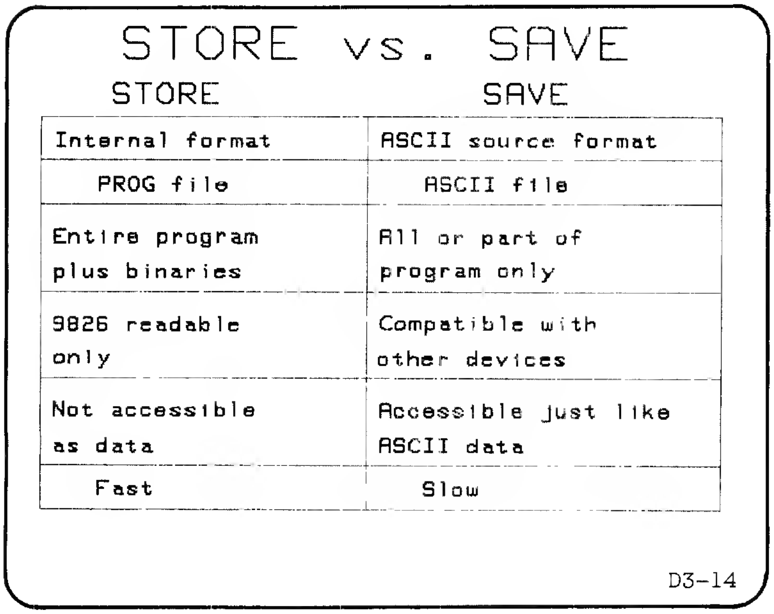
PROGRAM STORAGE SPECIFICS

- SAVE creates an ASCII file and writes all or part of the program to the file as data
- RE-SAVE does a SAVE, then removes old file of same name from the disc (Update)

```
SAVE "EDITOR"
RE-SAVE "EDITOR"
SAVE File_name$ & Media$
```

D3-13

NOTES



STORE vs. SAVE

STORE	SAVE
Internal format	ASCII source format
PROG file	ASCII file
Entire program plus binaries	All or part of program only
9826 readable only	Compatible with other devices
Not accessible as data	Accessible just like ASCII data
Fast	Slow

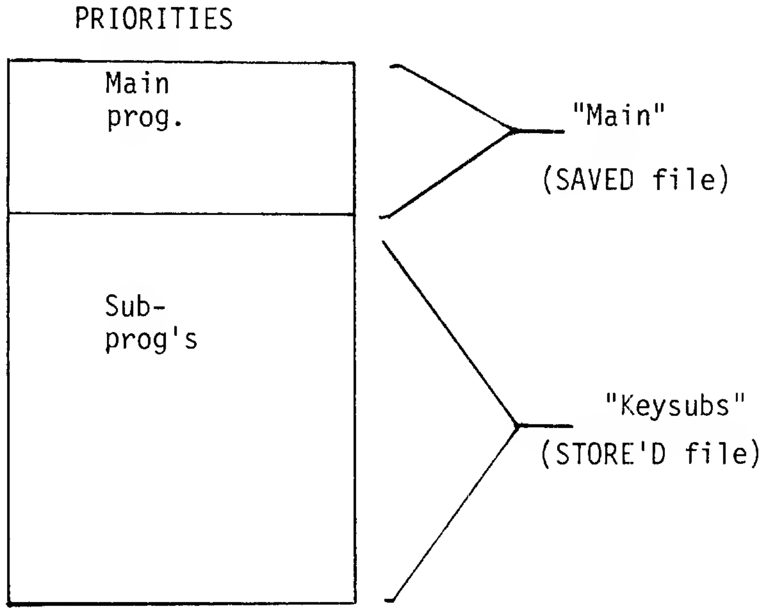
D3-14

NOTES

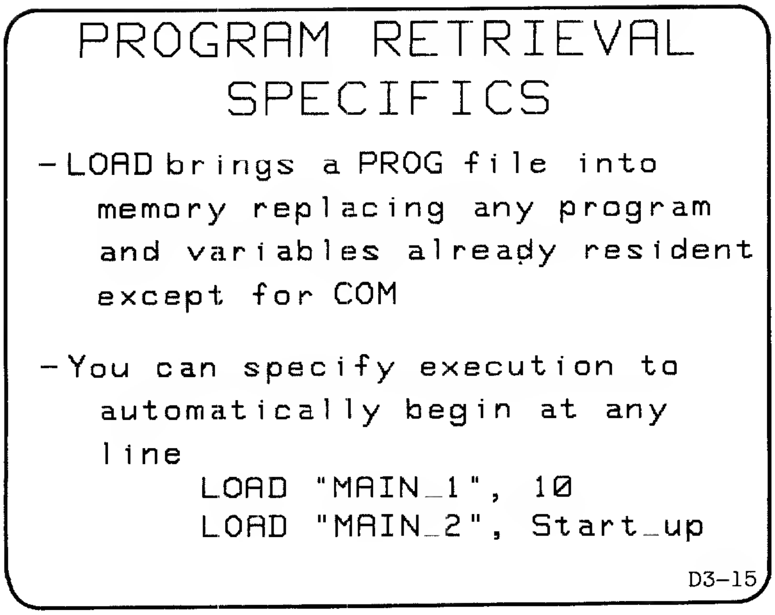
EXERCISE 13

GET "PRIORITIES" and edit the program.

Use combinations of SAVE, GET, and STORE to build two files from the program: one file the main program, the other file the key-service subprograms.



The challenge here is to determine how to produce a STORE'd program file of just the key-service subprograms. You will be using these files in a short time.



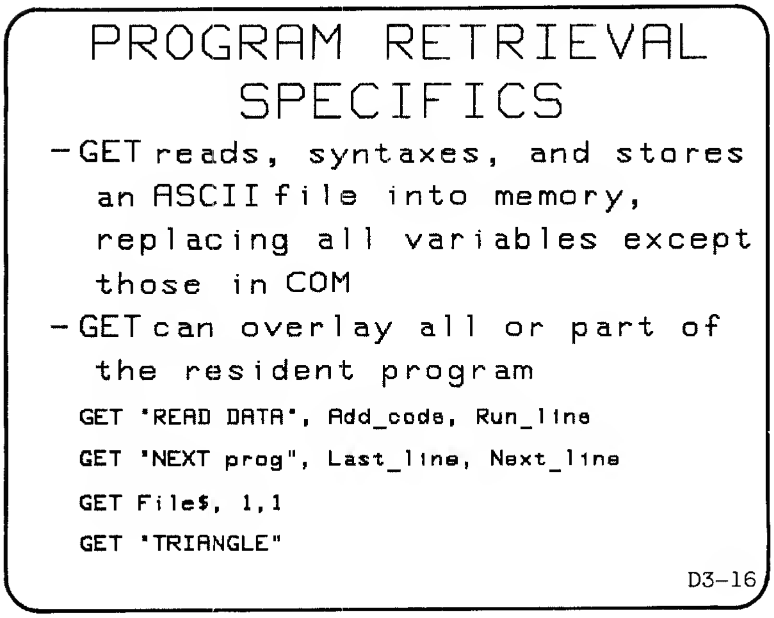
PROGRAM RETRIEVAL SPECIFICS

- LOAD brings a PROG file into memory replacing any program and variables already resident except for COM
- You can specify execution to automatically begin at any line

```
        LOAD "MAIN_1", 10
        LOAD "MAIN_2", Start_up
```

D3-15

NOTES



PROGRAM RETRIEVAL SPECIFICS

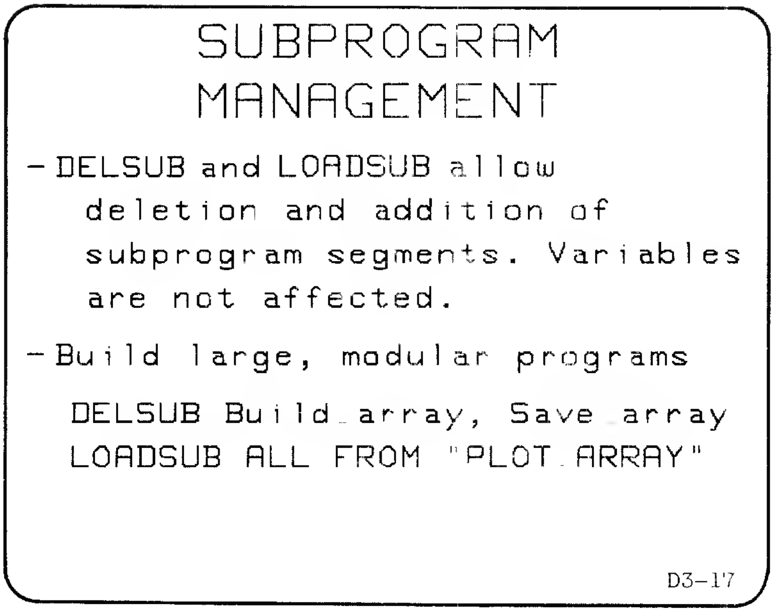
- GET reads, syntaxes, and stores an ASCII file into memory, replacing all variables except those in COM
- GET can overlay all or part of the resident program

```
GET "READ DATA", Add_code, Run_line
GET "NEXT prog", Last_line, Next_line
GET File$, 1,1
GET "TRIANGLE"
```

D3-16

NOTES

NOTES



SUBPROGRAM MANAGEMENT

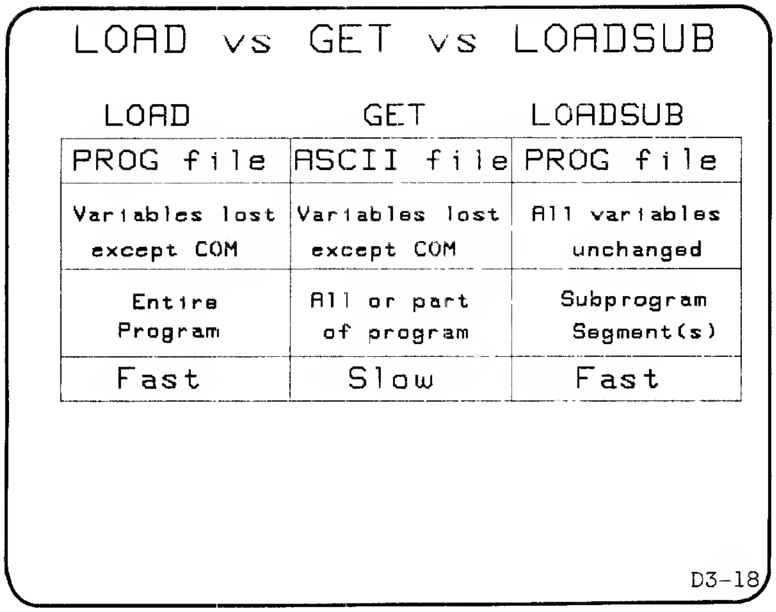
- DELSUB and LOADSUB allow deletion and addition of subprogram segments. Variables are not affected.
- Build large, modular programs

```
DELSUB Build_array, Save_array
LOADSUB ALL FROM "PLOT_ARRAY"
```

D3-17

EXERCISE 14

GET "Main" , the main-program file you saved previously, and modify it so that the program will run correctly. (You should need only to insert one line to be able to run it.) Be sure to re-save your main program if you want a running example for posterity.



LOAD vs GET vs LOADSUB

LOAD	GET	LOADSUB
PROG file	ASCII file	PROG file
Variables lost except COM	Variables lost except COM	All variables unchanged
Entire Program	All or part of program	Subprogram Segment(s)
Fast	Slow	Fast

D3-18

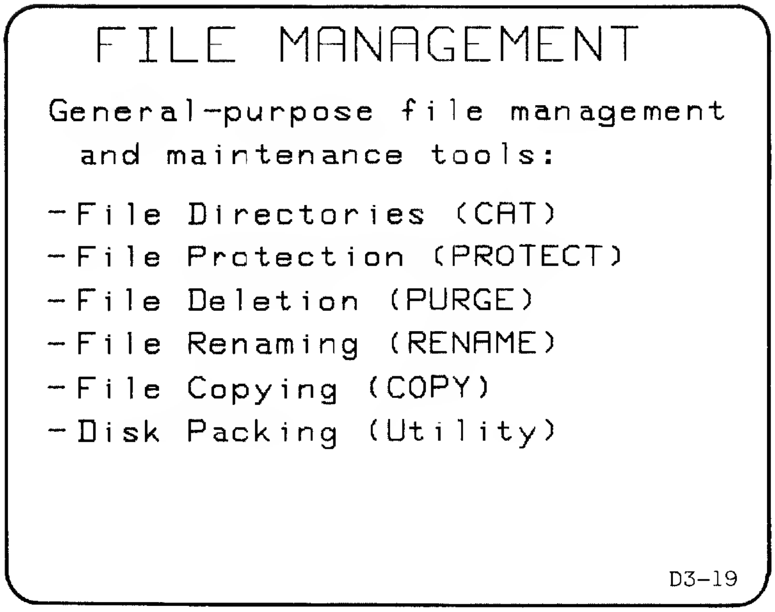
NOTES

EXERCISE 15

GET "GETLOADSUB" and list the program

Before running the program, try to predict what the values of the variables will be when the PRINT statements are executed. Run the program. Did it do what you expected?

NOTES



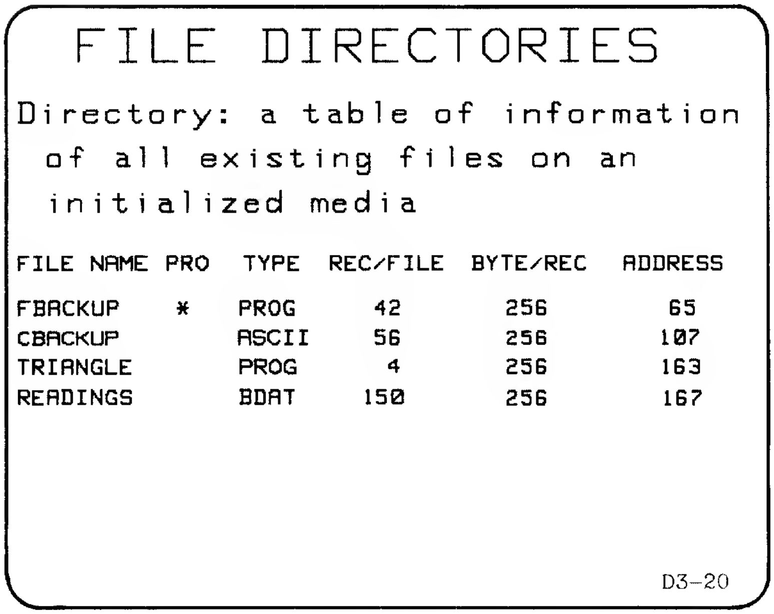
FILE MANAGEMENT

General-purpose file management and maintenance tools:

- File Directories (CAT)
- File Protection (PROTECT)
- File Deletion (PURGE)
- File Renaming (RENAME)
- File Copying (COPY)
- Disk Packing (Utility)

D3-19

NOTES

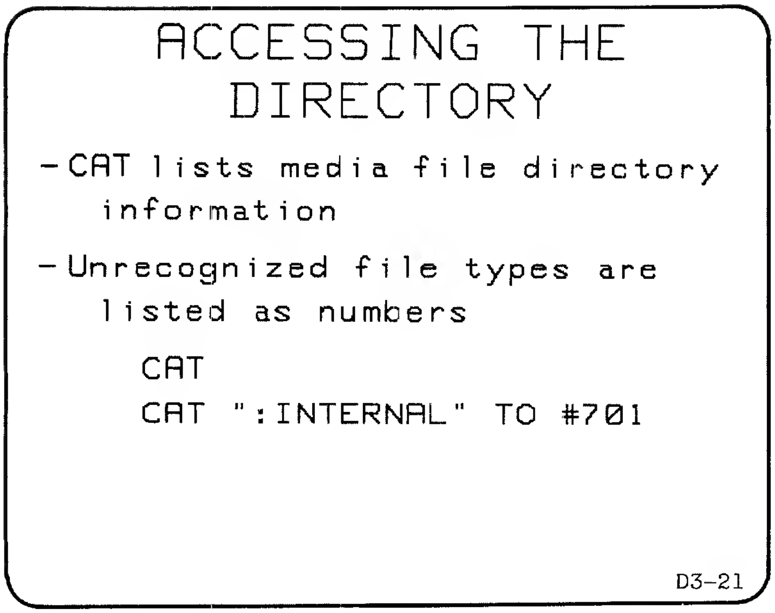


FILE DIRECTORIES

Directory: a table of information of all existing files on an initialized media

```
FILE NAME PRO   TYPE   REC/FILE   BYTE/REC    ADDRESS

FBACKUP    *    PROG      42        256         65
CBACKUP         ASCII     56        256        107
TRIANGLE        PROG       4        256        163
READINGS        BDAT     150        256        167
```

D3-20



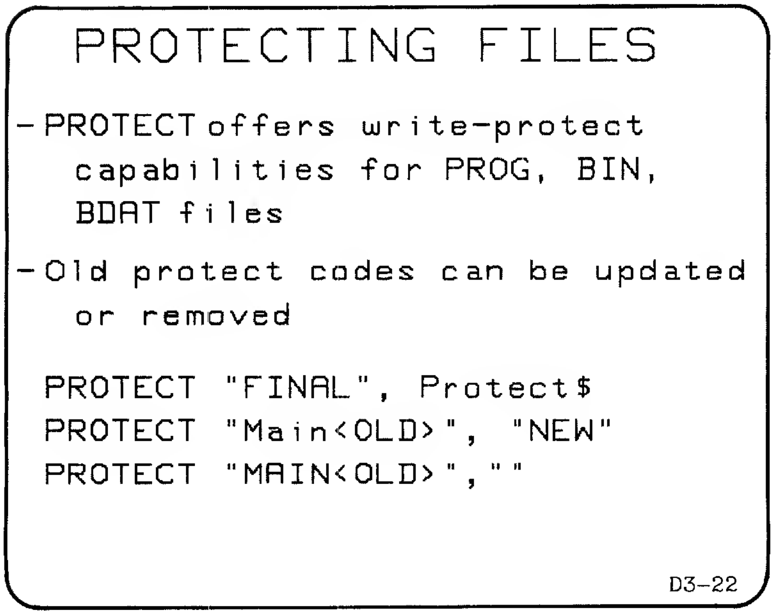
ACCESSING THE DIRECTORY

- CAT lists media file directory information
- Unrecognized file types are listed as numbers

```
CAT
CAT ":INTERNAL" TO #701
```

D3-21

NOTES



PROTECTING FILES

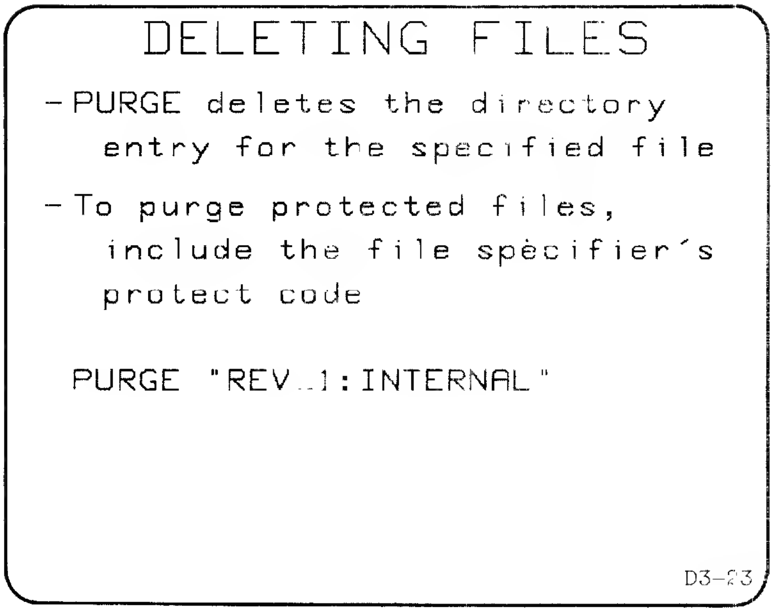
- PROTECT offers write-protect capabilities for PROG, BIN, BDAT files
- Old protect codes can be updated or removed

```
PROTECT "FINAL", Protect$
PROTECT "Main<OLD>", "NEW"
PROTECT "MAIN<OLD>",""
```

D3-22

NOTES

NOTES



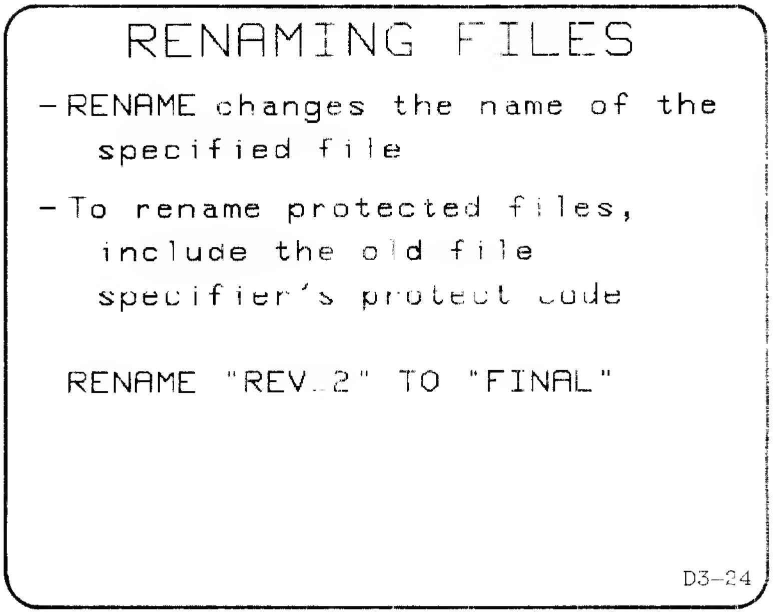
DELETING FILES

- PURGE deletes the directory entry for the specified file
- To purge protected files, include the file specifier's protect code

```
PURGE "REV_1:INTERNAL"
```

D3-23

NOTES

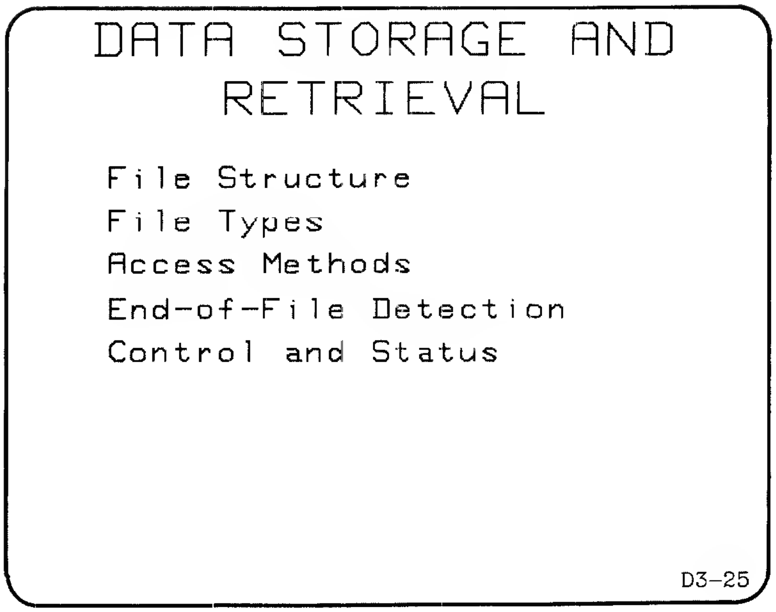


RENAMING FILES

- RENAME changes the name of the specified file
- To rename protected files, include the old file specifier's protect code

```
RENAME "REV_2" TO "FINAL"
```

D3-24

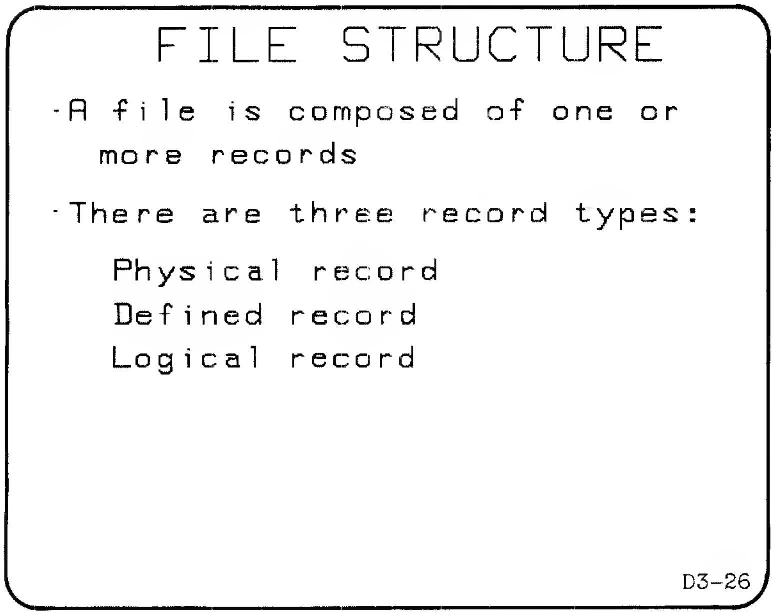


DATA STORAGE AND RETRIEVAL

File Structure
File Types
Access Methods
End-of-File Detection
Control and Status

D3-25

NOTES



FILE STRUCTURE

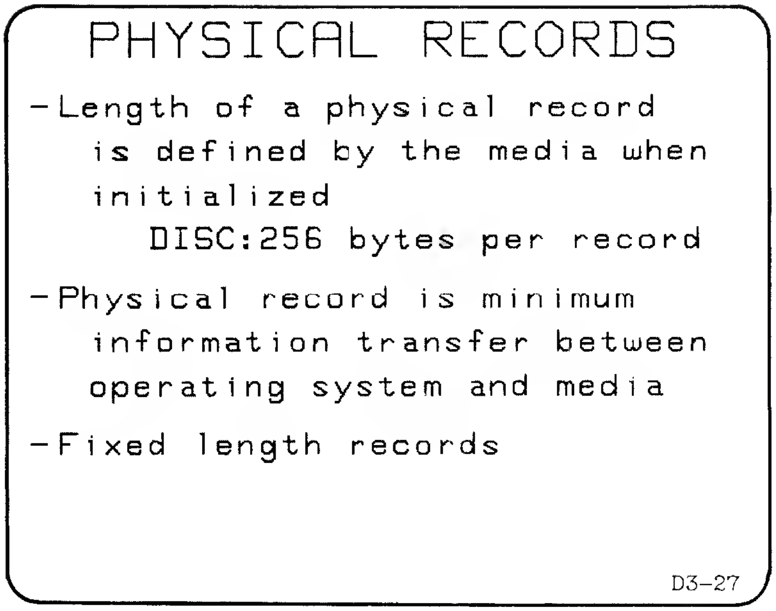
- A file is composed of one or more records
- There are three record types:

  Physical record
  Defined record
  Logical record

D3-26

NOTES

NOTES



PHYSICAL RECORDS

- Length of a physical record is defined by the media when initialized

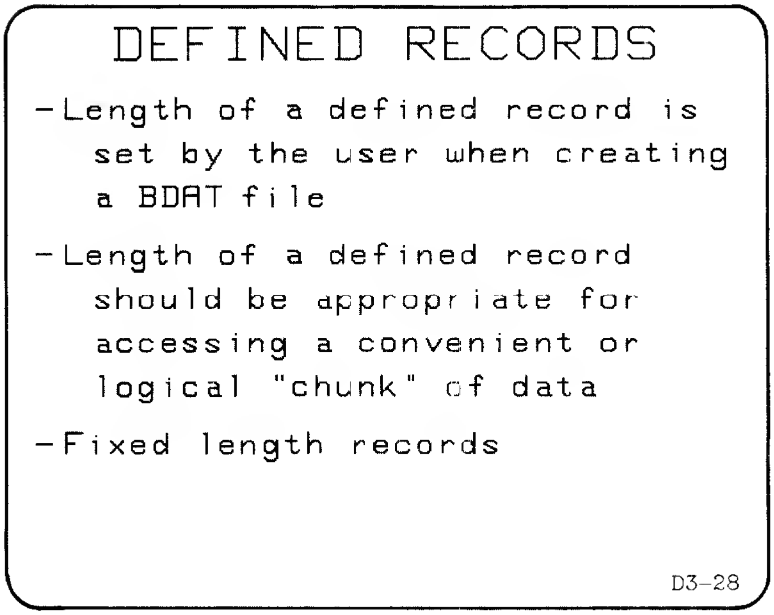
  DISC:256 bytes per record

- Physical record is minimum information transfer between operating system and media

- Fixed length records

D3-27

NOTES



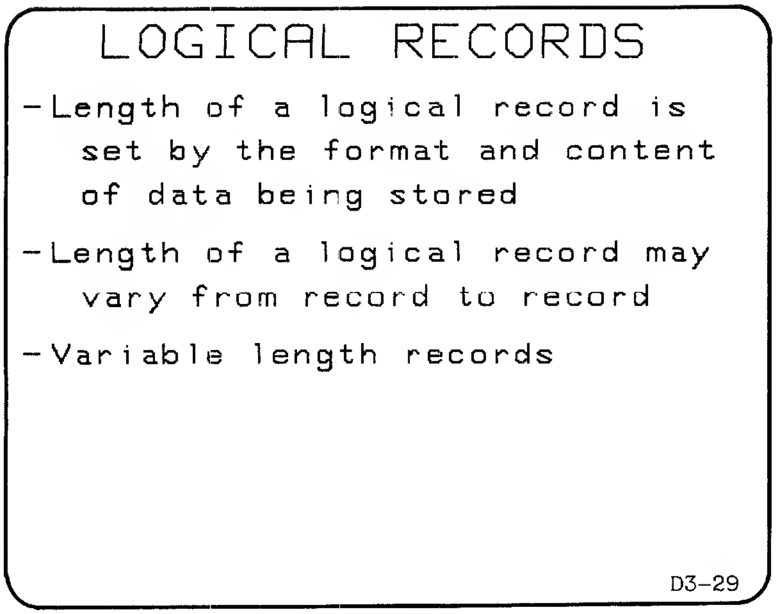
DEFINED RECORDS

- Length of a defined record is set by the user when creating a BDAT file

- Length of a defined record should be appropriate for accessing a convenient or logical "chunk" of data

- Fixed length records

D3-28

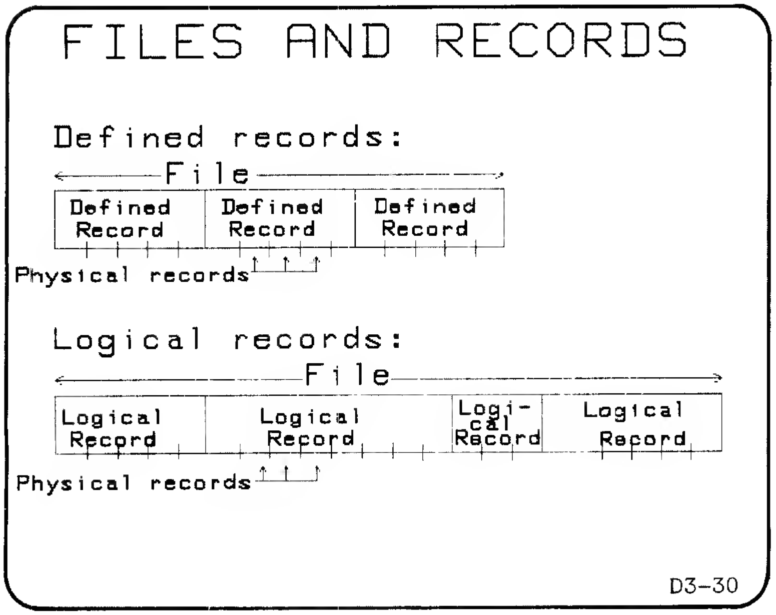


LOGICAL RECORDS

- Length of a logical record is set by the format and content of data being stored
- Length of a logical record may vary from record to record
- Variable length records

D3-29

NOTES



FILES AND RECORDS

Defined records:

File

Defined Record

Defined Record

Defined Record

Physical records

Logical records:

File

Logical Record

Logical Record

Logi-cal Record

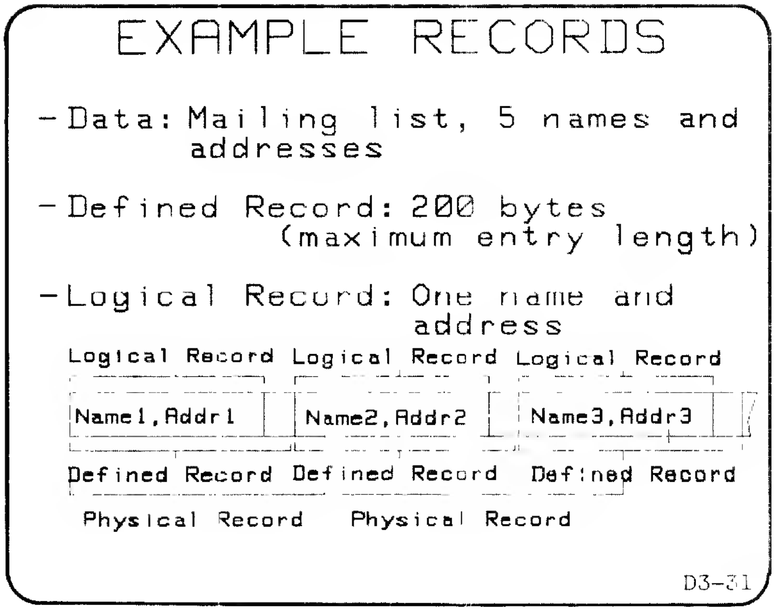
Logical Record

Physical records

D3-30

NOTES

NOTES



EXAMPLE RECORDS

- Data: Mailing list, 5 names and addresses
- Defined Record: 200 bytes (maximum entry length)
- Logical Record: One name and address

Logical Record Logical Record Logical Record

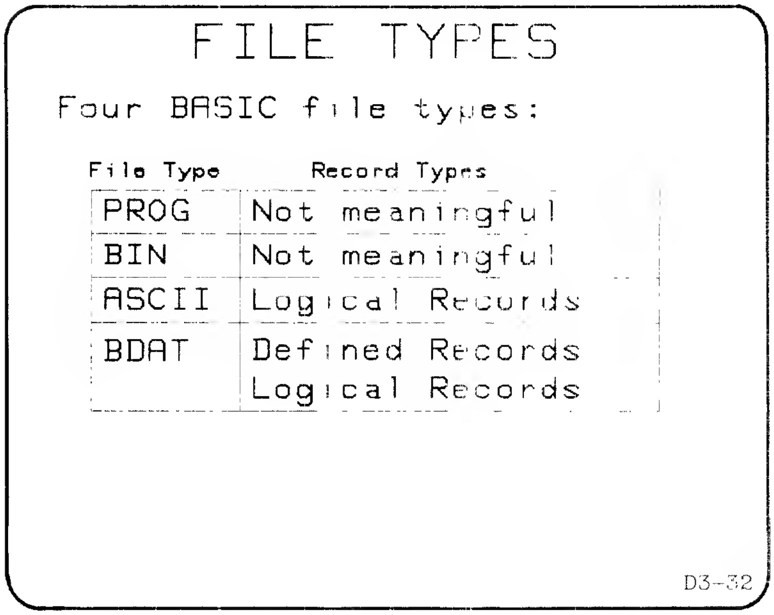
Name1,Addr1 Name2,Addr2 Name3,Addr3

Defined Record Defined Record Defined Record

Physical Record Physical Record

D3-31

NOTES

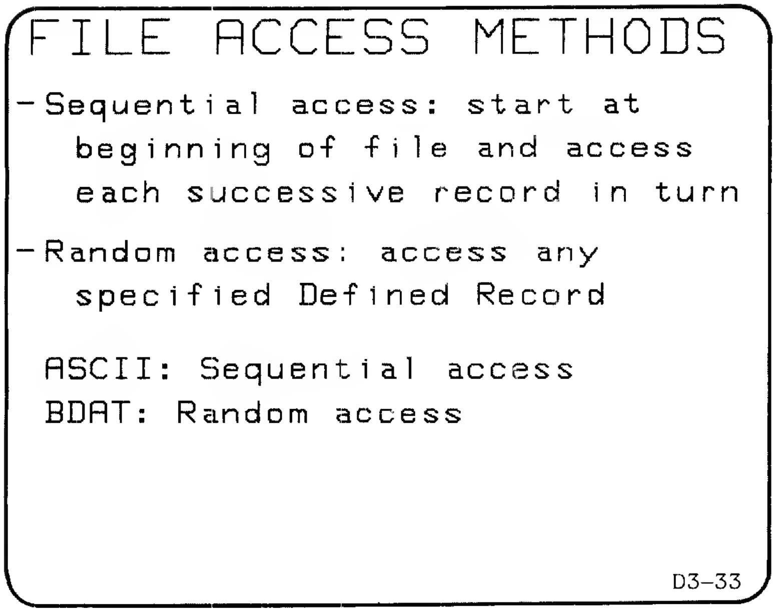


FILE TYPES

Four BASIC file types:

File Type	Record Types
PROG	Not meaningful
BIN	Not meaningful
ASCII	Logical Records
BDAT	Defined Records Logical Records

D3-32



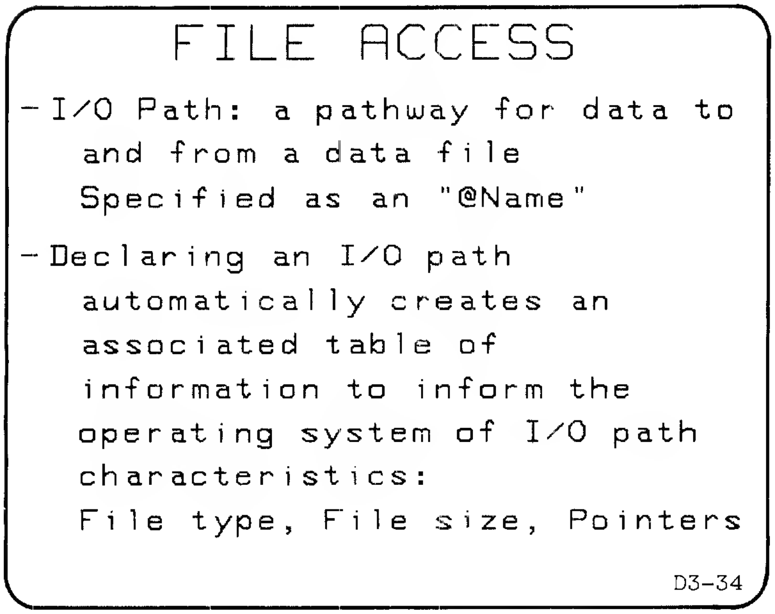
FILE ACCESS METHODS

- Sequential access: start at beginning of file and access each successive record in turn
- Random access: access any specified Defined Record

ASCII: Sequential access
BDAT: Random access

D3-33

NOTES



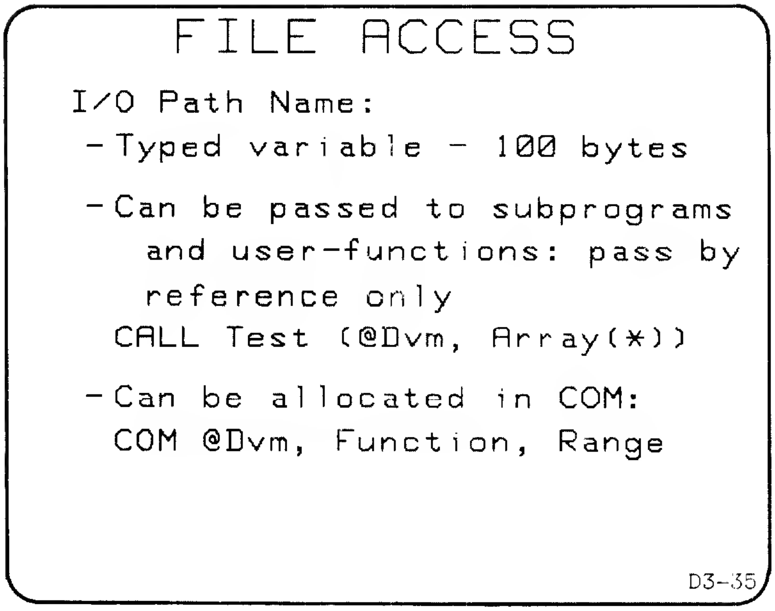
FILE ACCESS

- I/O Path: a pathway for data to and from a data file
  Specified as an "@Name"
- Declaring an I/O path automatically creates an associated table of information to inform the operating system of I/O path characteristics:
  File type, File size, Pointers

D3-34

NOTES

NOTES



FILE ACCESS

I/O Path Name:

- Typed variable - 100 bytes
- Can be passed to subprograms and user-functions: pass by reference only

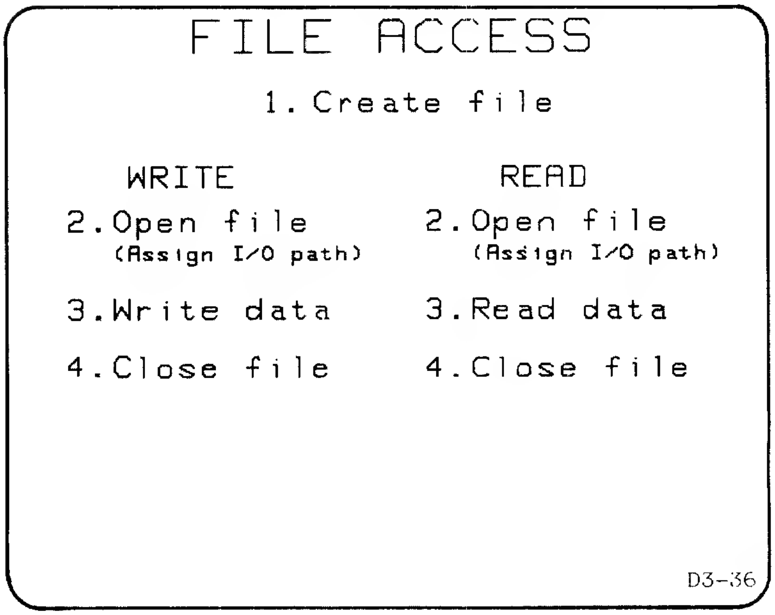
```
CALL Test (@Dvm, Array(*))
```

- Can be allocated in COM:

```
COM @Dvm, Function, Range
```

D3-35

NOTES

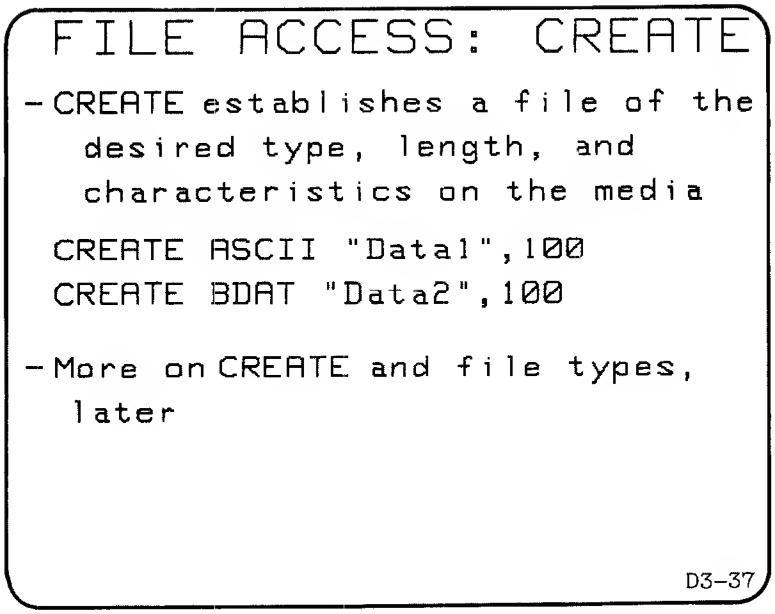


FILE ACCESS

1. Create file

WRITE	READ
2. Open file (Assign I/O path)	2. Open file (Assign I/O path)
3. Write data	3. Read data
4. Close file	4. Close file

D3-36



FILE ACCESS: CREATE

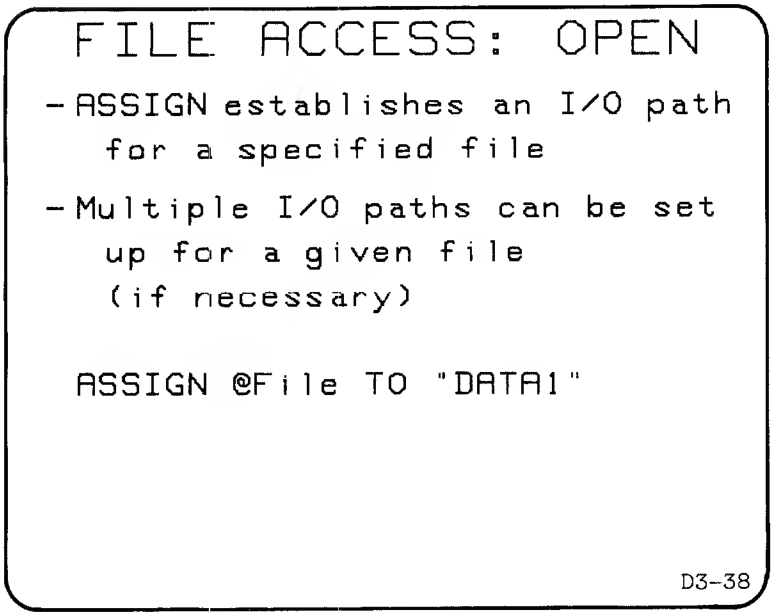
- CREATE establishes a file of the desired type, length, and characteristics on the media

```
CREATE ASCII "Data1",100
CREATE BDAT "Data2",100
```

- More on CREATE and file types, later

D3-37

NOTES



FILE ACCESS: OPEN

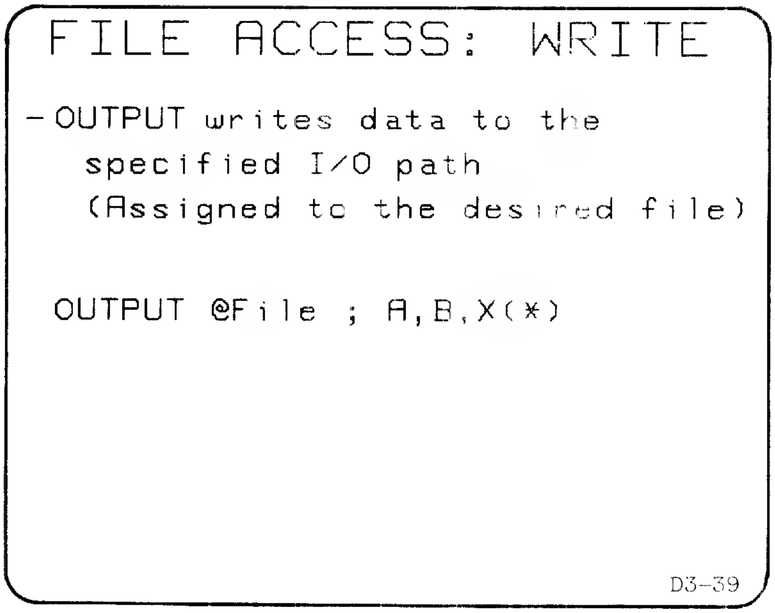
- ASSIGN establishes an I/O path for a specified file
- Multiple I/O paths can be set up for a given file (if necessary)

```
ASSIGN @File TO "DATA1"
```

D3-38

NOTES

NOTES



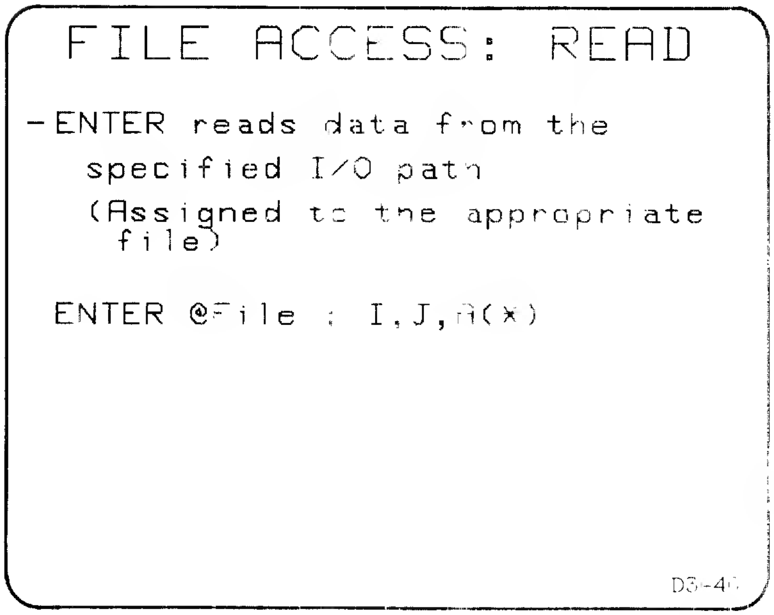
FILE ACCESS: WRITE

- OUTPUT writes data to the specified I/O path (Assigned to the desired file)

```
OUTPUT @File ; A,B,X(*)
```

D3-39

NOTES

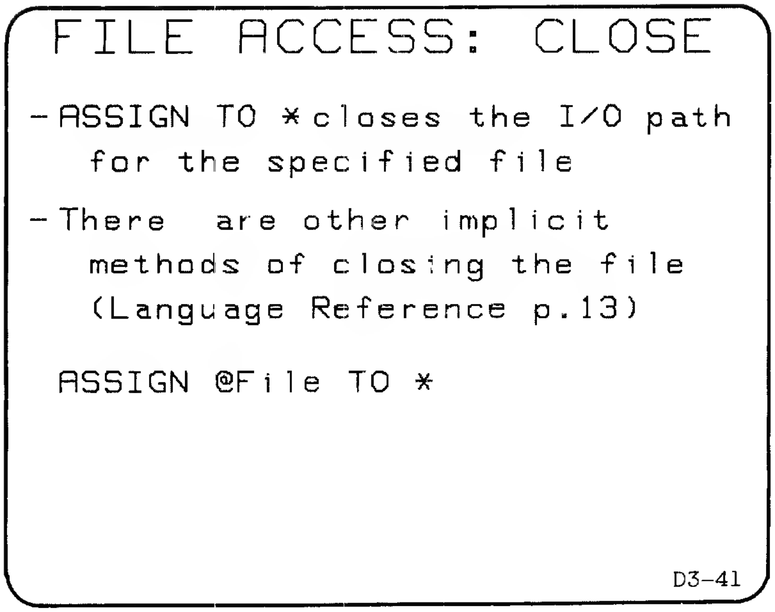


FILE ACCESS: READ

- ENTER reads data from the specified I/O path (Assigned to the appropriate file)

```
ENTER @File ; I,J,A(*)
```

D3-40



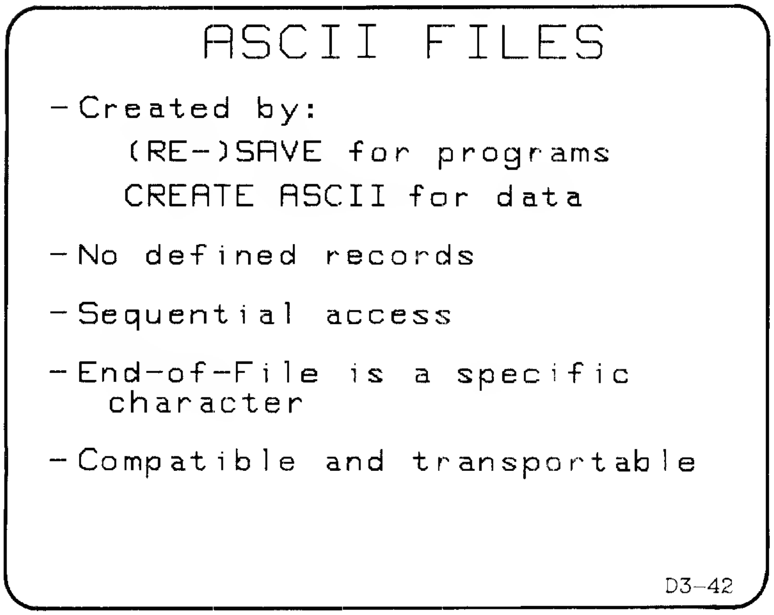
FILE ACCESS: CLOSE

- ASSIGN TO *closes the I/O path for the specified file
- There are other implicit methods of closing the file (Language Reference p.13)

```
ASSIGN @File TO *
```

D3-41

NOTES



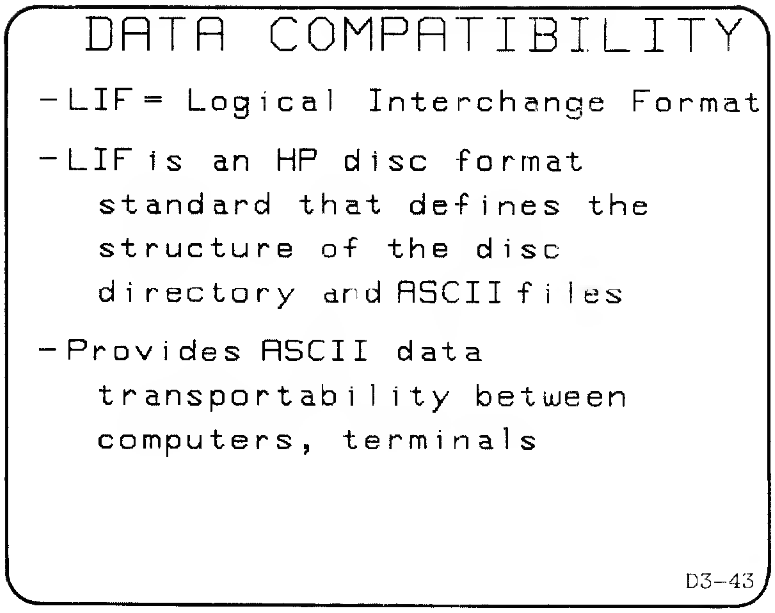
ASCII FILES

- Created by:
  (RE-)SAVE for programs
  CREATE ASCII for data
- No defined records
- Sequential access
- End-of-File is a specific character
- Compatible and transportable

D3-42

NOTES

NOTES

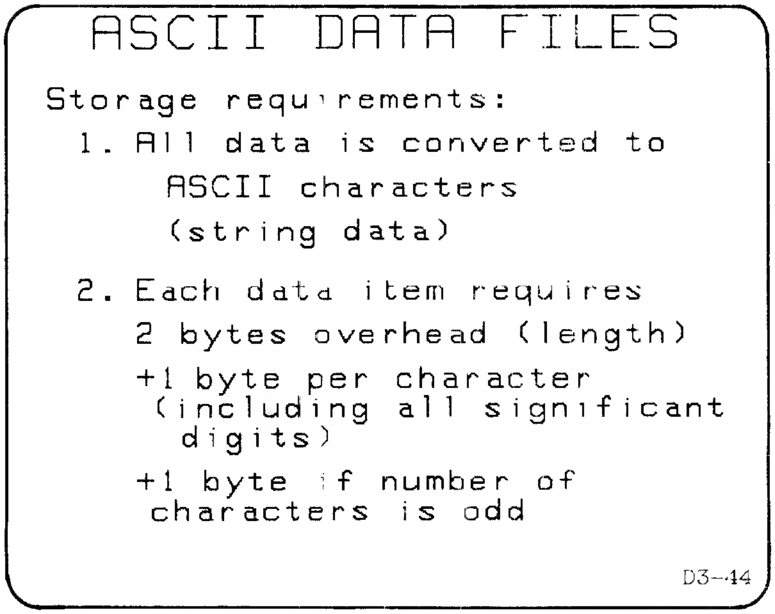


DATA COMPATIBILITY

- LIF = Logical Interchange Format
- LIF is an HP disc format standard that defines the structure of the disc directory and ASCII files
- Provides ASCII data transportability between computers, terminals

D3-43

NOTES

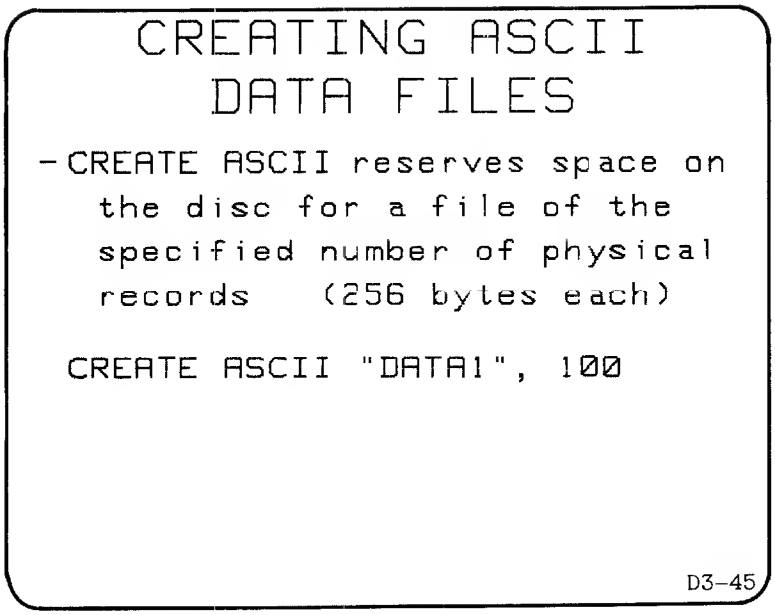


ASCII DATA FILES

Storage requirements:

1. All data is converted to ASCII characters (string data)
2. Each data item requires
   2 bytes overhead (length)
   +1 byte per character (including all significant digits)
   +1 byte if number of characters is odd

D3-44



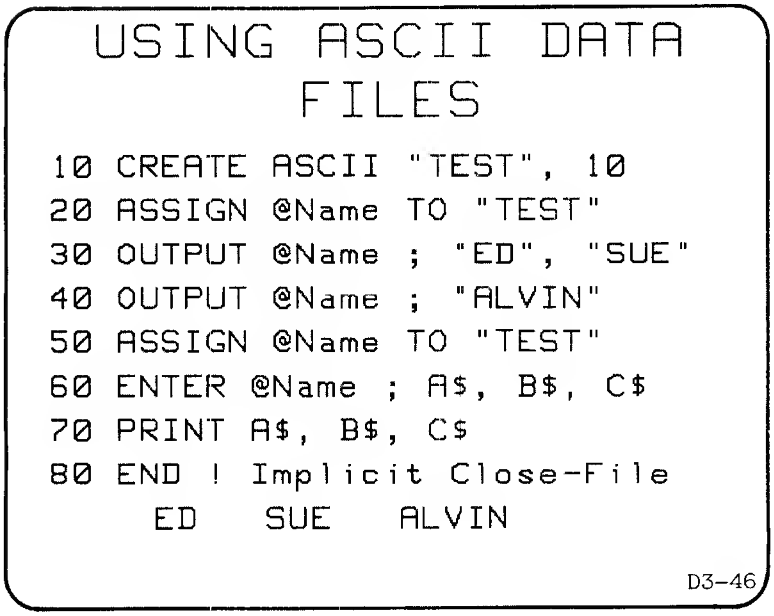
CREATING ASCII DATA FILES

- CREATE ASCII reserves space on the disc for a file of the specified number of physical records (256 bytes each)

```
CREATE ASCII "DATA1", 100
```

D3-45

NOTES



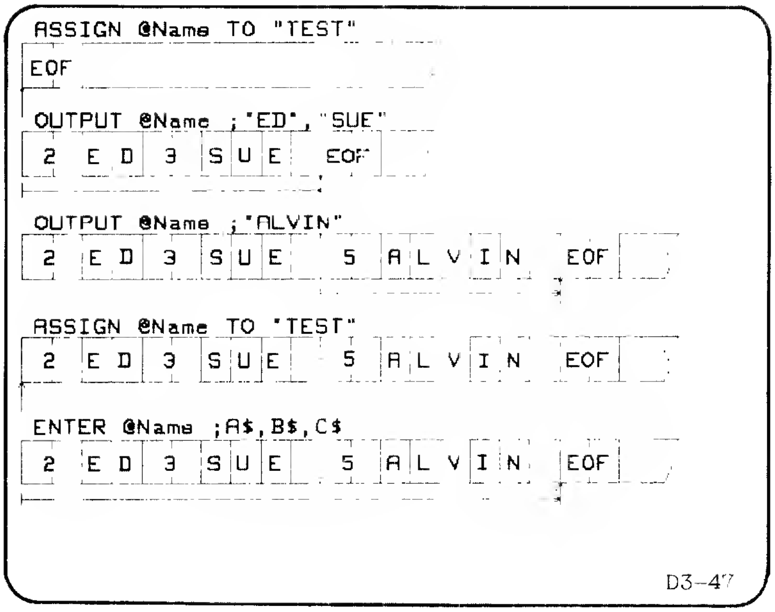
USING ASCII DATA FILES

```
10 CREATE ASCII "TEST", 10
20 ASSIGN @Name TO "TEST"
30 OUTPUT @Name ; "ED", "SUE"
40 OUTPUT @Name ; "ALVIN"
50 ASSIGN @Name TO "TEST"
60 ENTER @Name ; A$, B$, C$
70 PRINT A$, B$, C$
80 END ! Implicit Close-File
     ED    SUE    ALVIN
```

D3-46

NOTES

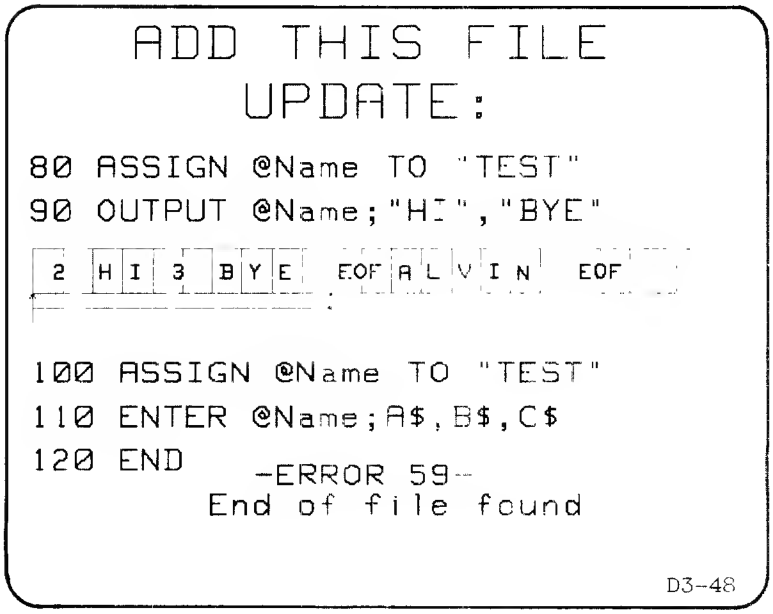
NOTES



```
ASSIGN @Name TO "TEST"
EOF

OUTPUT @Name ;"ED","SUE"
2 E D 3 S U E EOF

OUTPUT @Name ;"ALVIN"
2 E D 3 S U E 5 A L V I N EOF

ASSIGN @Name TO "TEST"
2 E D 3 S U E 5 A L V I N EOF

ENTER @Name ;A$,B$,C$
2 E D 3 S U E 5 A L V I N EOF
```

D3-47

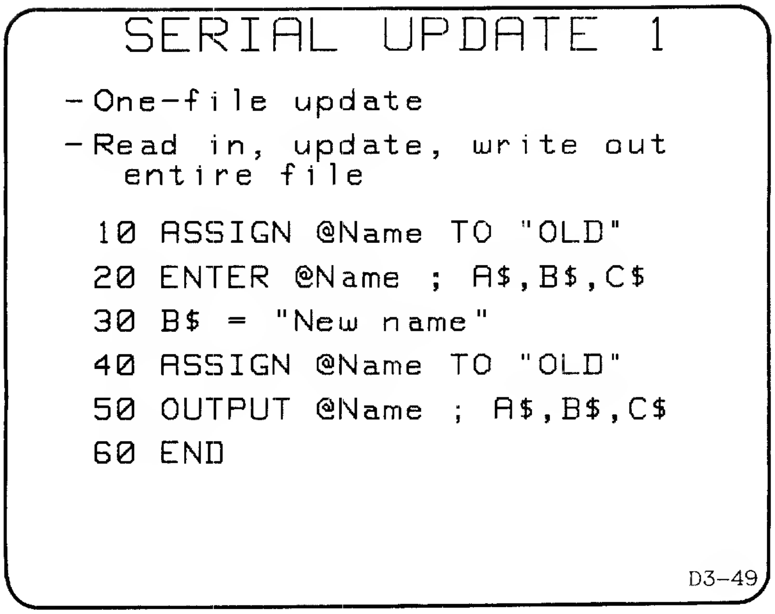
NOTES



ADD THIS FILE UPDATE:

```
80 ASSIGN @Name TO "TEST"
90 OUTPUT @Name;"HI","BYE"

2 H I 3 B Y E EOF A L V I N EOF

100 ASSIGN @Name TO "TEST"
110 ENTER @Name;A$,B$,C$
120 END
              -ERROR 59-
          End of file found
```

D3-48



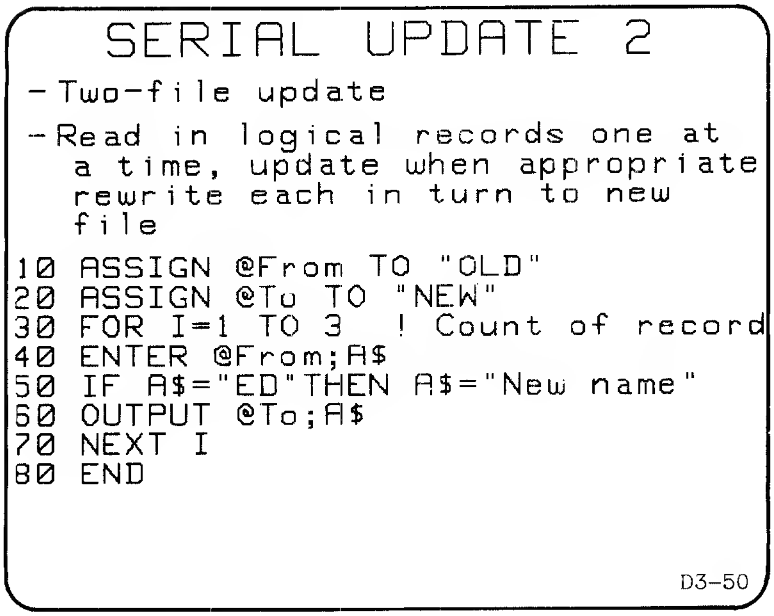
SERIAL UPDATE 1

- One-file update
- Read in, update, write out entire file

```
10 ASSIGN @Name TO "OLD"
20 ENTER @Name ; A$,B$,C$
30 B$ = "New name"
40 ASSIGN @Name TO "OLD"
50 OUTPUT @Name ; A$,B$,C$
60 END
```

D3-49

NOTES



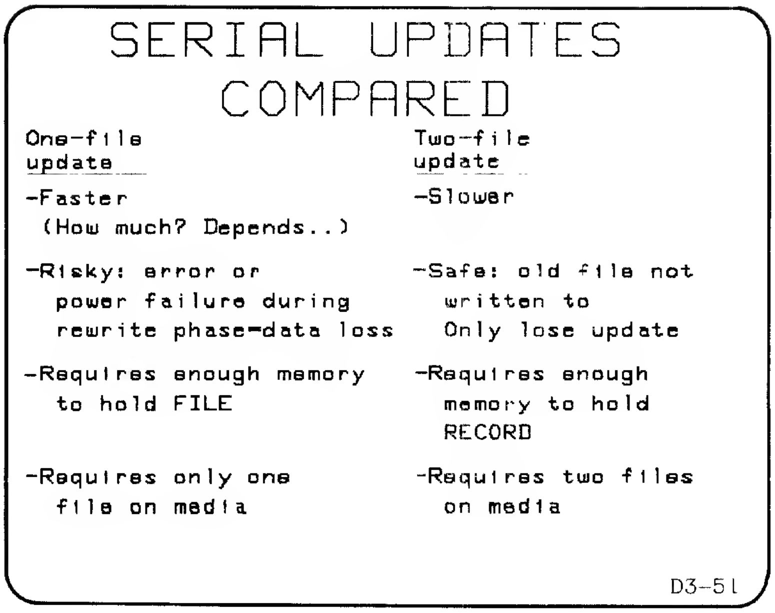
SERIAL UPDATE 2

- Two-file update
- Read in logical records one at a time, update when appropriate rewrite each in turn to new file

```
10 ASSIGN @From TO "OLD"
20 ASSIGN @To TO "NEW"
30 FOR I=1 TO 3  ! Count of record
40 ENTER @From;A$
50 IF A$="ED"THEN A$="New name"
60 OUTPUT @To;A$
70 NEXT I
80 END
```

D3-50

NOTES



SERIAL UPDATES COMPARED

One-file update	Two-file update
-Faster (How much? Depends..)	-Slower
-Risky: error or power failure during rewrite phase-data loss	-Safe: old file not written to Only lose update
-Requires enough memory to hold FILE	-Requires enough memory to hold RECORD
-Requires only one file on media	-Requires two files on media

D3-51

EXERCISE 16

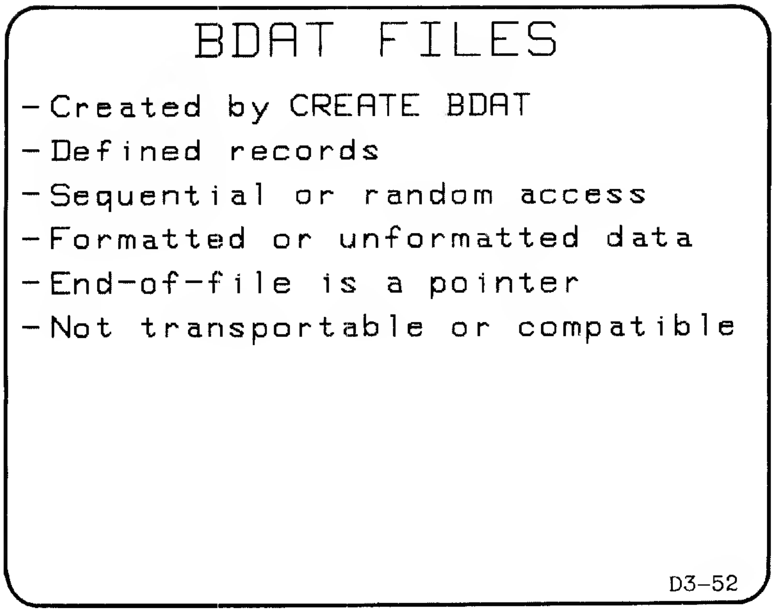
Write a program that updates the data on file "OLD_DATA" , using either update technique that was discussed.

- Data to be changed:
  1. Any occurrence of "Nabraska" to "Nebraska"
  2. Any occurrence of "Misissippi" to "Mississippi"

- Number of data items : 20
- Maximum length of any item : 20 characters

For your own information , have the program print out any data item that is updated, and the number of the data item.

```
(PRINT A$; TAB(20); I)
```

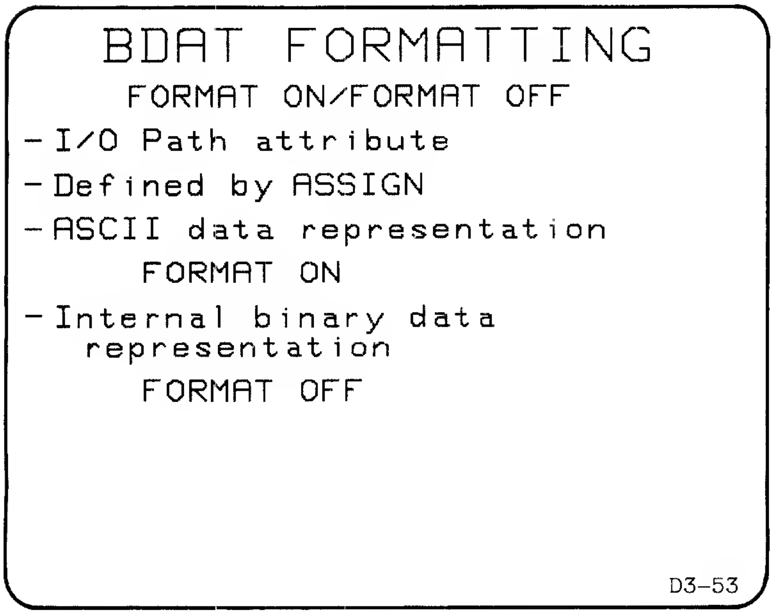


BDAT FILES

- Created by CREATE BDAT
- Defined records
- Sequential or random access
- Formatted or unformatted data
- End-of-file is a pointer
- Not transportable or compatible

D3-52

NOTES



BDAT FORMATTING

FORMAT ON/FORMAT OFF

- I/O Path attribute
- Defined by ASSIGN
- ASCII data representation

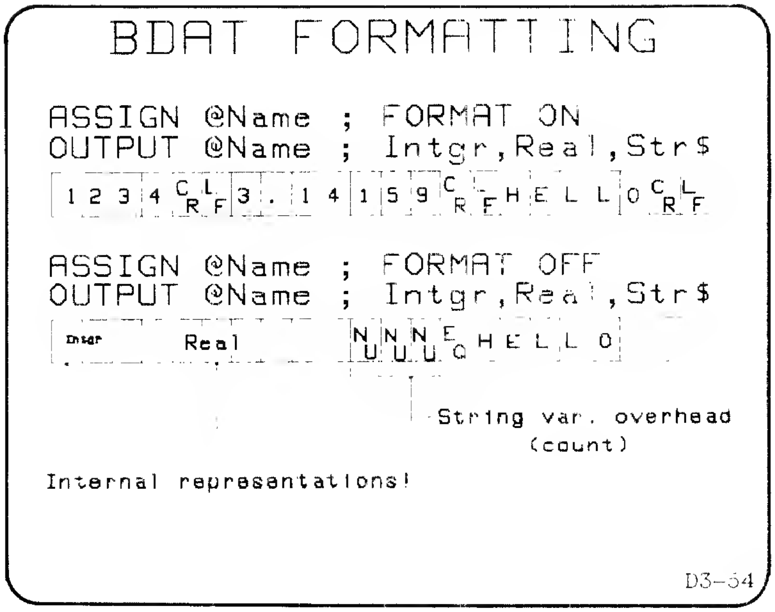
  FORMAT ON
- Internal binary data representation

  FORMAT OFF

D3-53

NOTES

NOTES



BDAT FORMATTING

```
ASSIGN @Name ; FORMAT ON
OUTPUT @Name ; Intgr,Real,Str$
```

1	2	3	4	CR	LF	3	.	1	4	1	5	9	CR	LF	H	E	L	L	O	CR	LF

```
ASSIGN @Name ; FORMAT OFF
OUTPUT @Name ; Intgr,Real,Str$
```

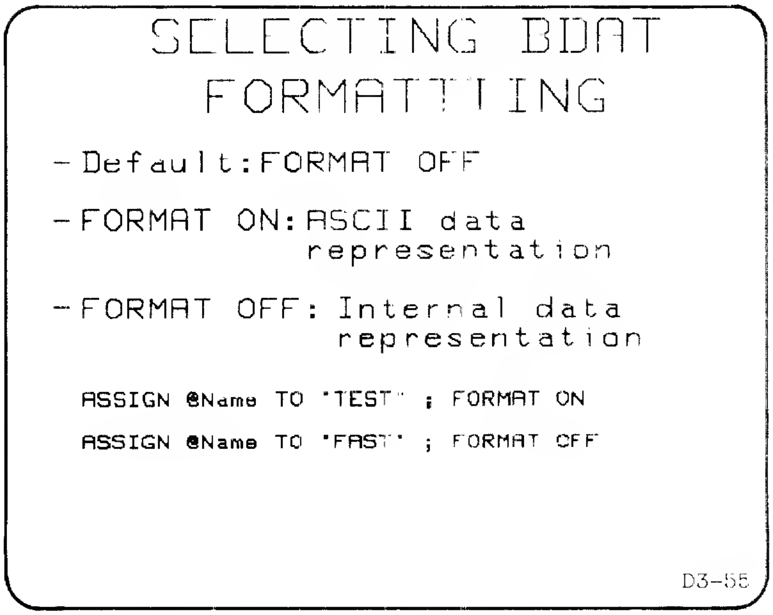
Intgr	Real	NU	NU	NU	EQ	H	E	L	L	O

String var. overhead (count)

Internal representations!

D3-54

NOTES

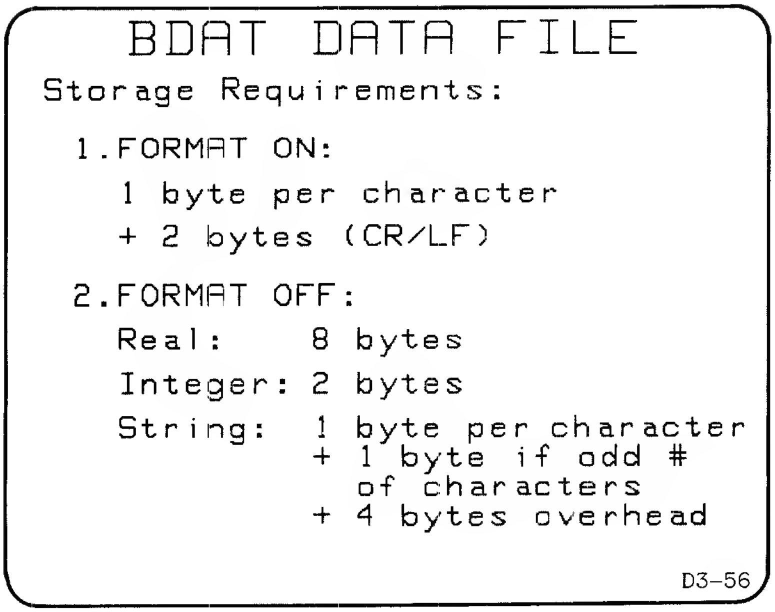


SELECTING BDAT FORMATTING

- Default: FORMAT OFF
- FORMAT ON: ASCII data representation
- FORMAT OFF: Internal data representation

```
ASSIGN @Name TO "TEST" ; FORMAT ON
ASSIGN @Name TO "FAST" ; FORMAT OFF
```

D3-55



BDAT DATA FILE

Storage Requirements:

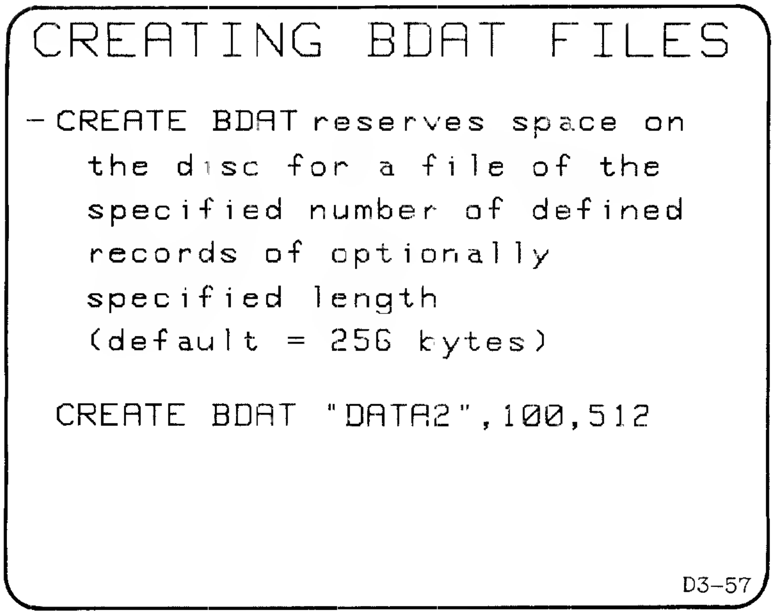
1. FORMAT ON:
   1 byte per character
   + 2 bytes (CR/LF)

2. FORMAT OFF:

```
Real:     8 bytes
Integer:  2 bytes
String:   1 byte per character
          + 1 byte if odd #
            of characters
          + 4 bytes overhead
```

D3-56

NOTES



CREATING BDAT FILES

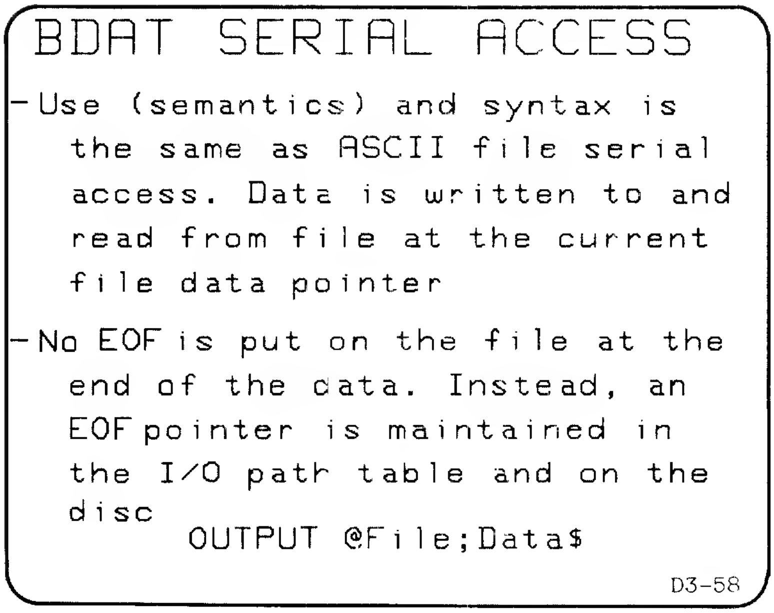
- CREATE BDAT reserves space on the disc for a file of the specified number of defined records of optionally specified length (default = 256 bytes)

```
CREATE BDAT "DATA2",100,512
```

D3-57

NOTES

NOTES



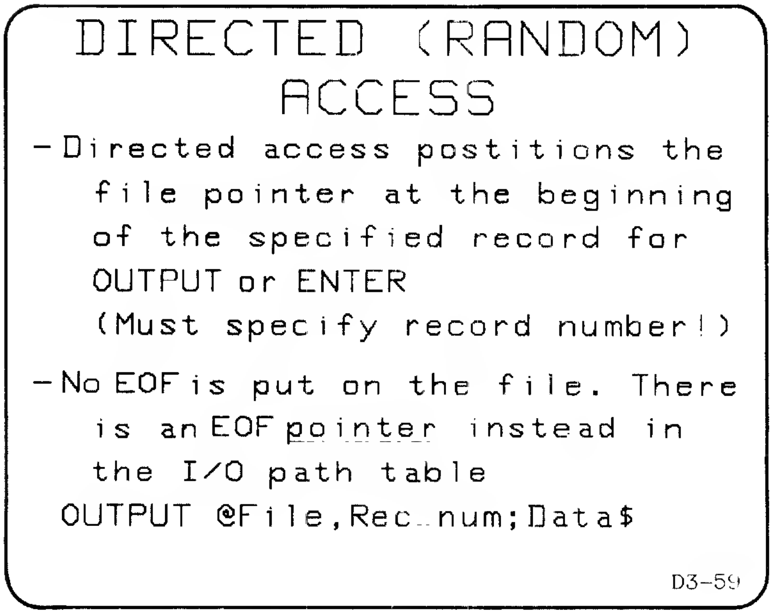
BDAT SERIAL ACCESS

- Use (semantics) and syntax is the same as ASCII file serial access. Data is written to and read from file at the current file data pointer
- No EOF is put on the file at the end of the data. Instead, an EOF pointer is maintained in the I/O path table and on the disc

```
OUTPUT @File;Data$
```

D3-58

NOTES



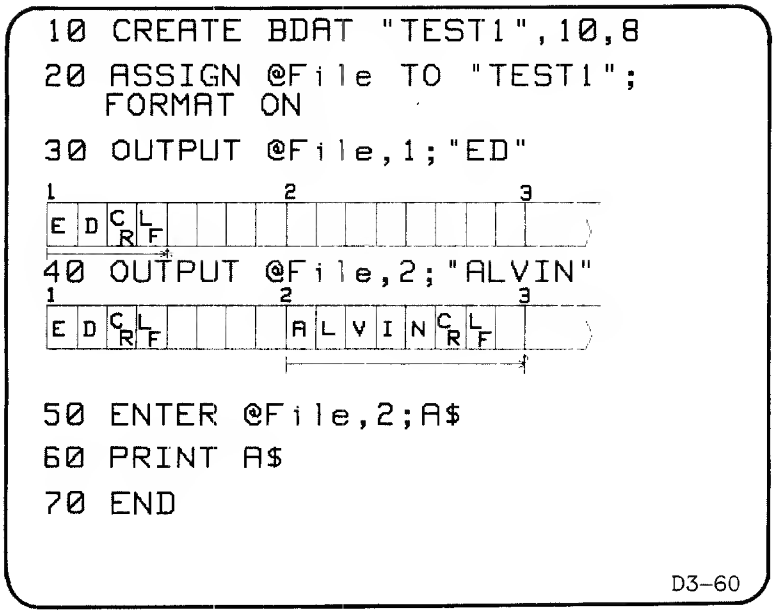
DIRECTED (RANDOM) ACCESS

- Directed access postitions the file pointer at the beginning of the specified record for OUTPUT or ENTER (Must specify record number!)
- No EOF is put on the file. There is an EOF pointer instead in the I/O path table

```
OUTPUT @File,Rec_num;Data$
```

D3-59

NOTES



```
10 CREATE BDAT "TEST1",10,8
20 ASSIGN @File TO "TEST1";
   FORMAT ON
30 OUTPUT @File,1;"ED"
```

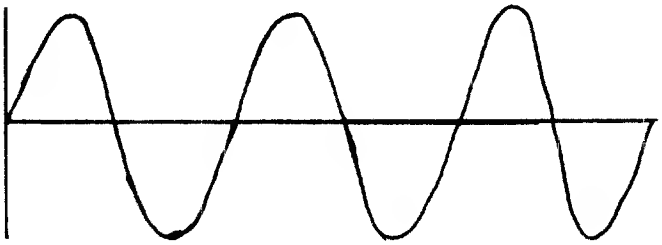
```
40 OUTPUT @File,2;"ALVIN"
```

```
50 ENTER @File,2;A$
60 PRINT A$
70 END
```

D3-60

EXERCISE 17

Write a program that puts 100 numeric data items on a BDAT data file. The values for these data items are from a 3-cycle sine wave that your program will calculate. Pictorially, the data will look like this:



1. Create a data file "SIN-DAT", either
   - a. 100 records of 8 bytes/record (Directed Access), or
   - b. 1 record of 800 bytes (Serial Access)
2. Generate the data
   - a. Range of -10 to +10 (10*SIN(X))
   - b. Use a FOR/NEXT LOOP?

     Array(I)=SIN(I*360*3/100)*10
3. Write the data to your file using the appropriate access method.

Note: The solution program creates a serial access file.

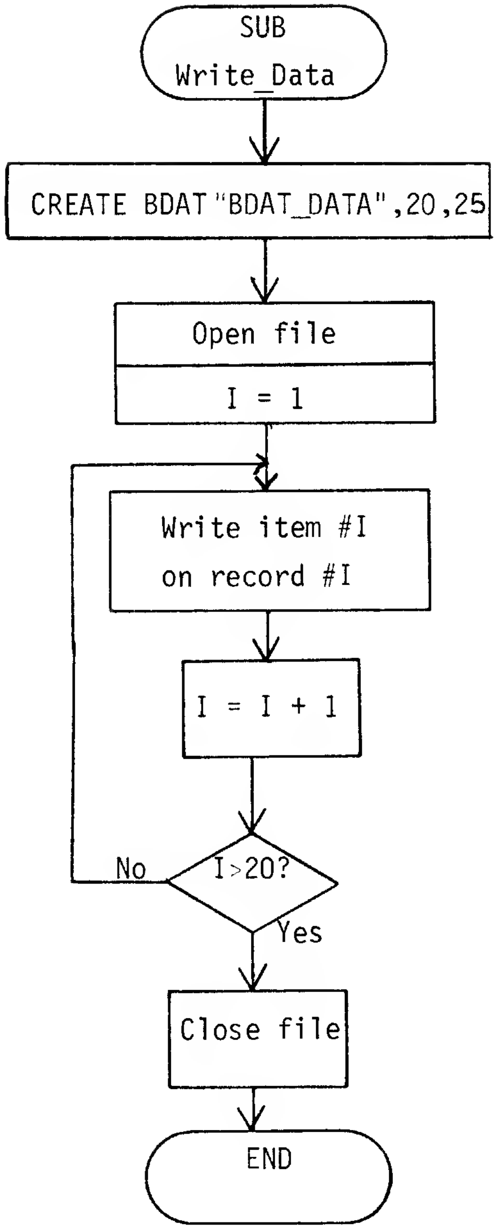
EXERCISE 18

Write a subprogram that creates a BDAT data file, then outputs 20 string data items (one per record) to the file. The data items will be passed to your subprogram as a string array in the parameter list.

- Name of your subprogram:	Write_data
- File name of your subprogram:	"WRITEBDAT"
- Create a BDAT file of:	20 records, 25 bytes/record
- Name of BDAT file::	"BDAT_DATA"
- Parameter list:	(Data$(*))

After you write the subprogram and store it on the file, GET "BLD_DATA" and run it. Your subprogram will be loaded and called. When everything has completed, the data file should look like this:

	Record 1	Record 2	Record 3	
Data File :	Data$(1)	Data$(2)	Data$(3)	. . .


SUB
Write_Data
CREATE BDAT "BDAT_DATA",20,25
Open file
I = 1
Write item #I
on record #I
I = I + 1
I>20?
No
Yes
Close file
END

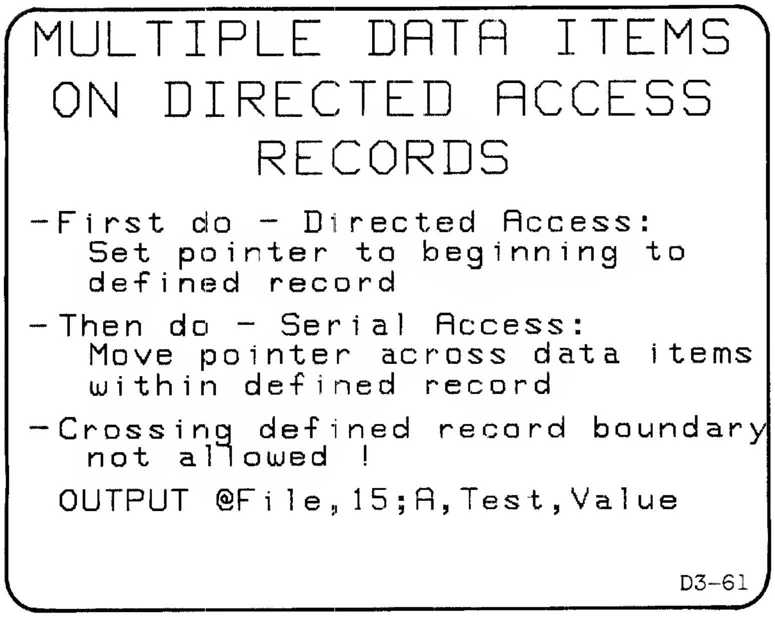
EXERCISE 19

Write a program to retrieve and print the 20 data items on file "BDAT_DATA" (A FOR-NEXT loop would be OK). Your program should then ask which items need to be modified, input the corrected items, and rewrite them to the file. (Don't rewrite all the items, only the corrected ones). Remember, this file is a directed-access file so your program will have to keep track of the associated record number for each data item.

Some records you might wish to update are:

1
2
9
14
15

(They are misspelled.)



MULTIPLE DATA ITEMS ON DIRECTED ACCESS RECORDS

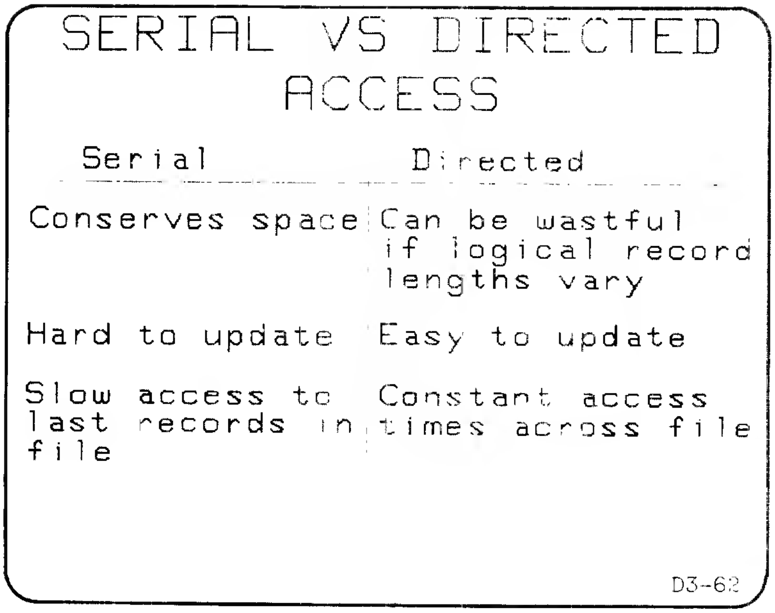
- First do - Directed Access:
  Set pointer to beginning to defined record
- Then do - Serial Access:
  Move pointer across data items within defined record
- Crossing defined record boundary not allowed !

OUTPUT @File,15;A,Test,Value

D3-61

NOTES

NOTES

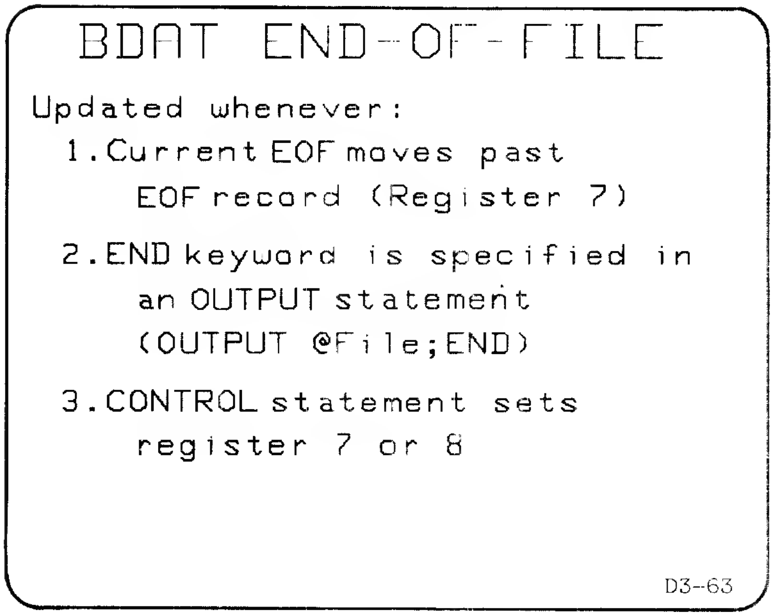


SERIAL VS DIRECTED ACCESS

Serial	Directed
Conserves space	Can be wastful if logical record lengths vary
Hard to update	Easy to update
Slow access to last records in file	Constant access times across file

D3-62

NOTES

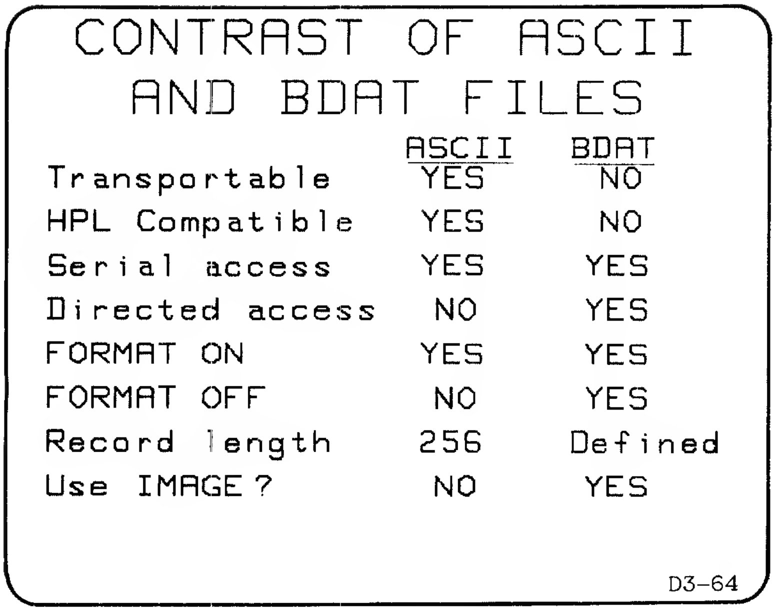


BDAT END-OF-FILE

Updated whenever:

1. Current EOF moves past EOF record (Register 7)
2. END keyword is specified in an OUTPUT statement (OUTPUT @File;END)
3. CONTROL statement sets register 7 or 8

D3-63

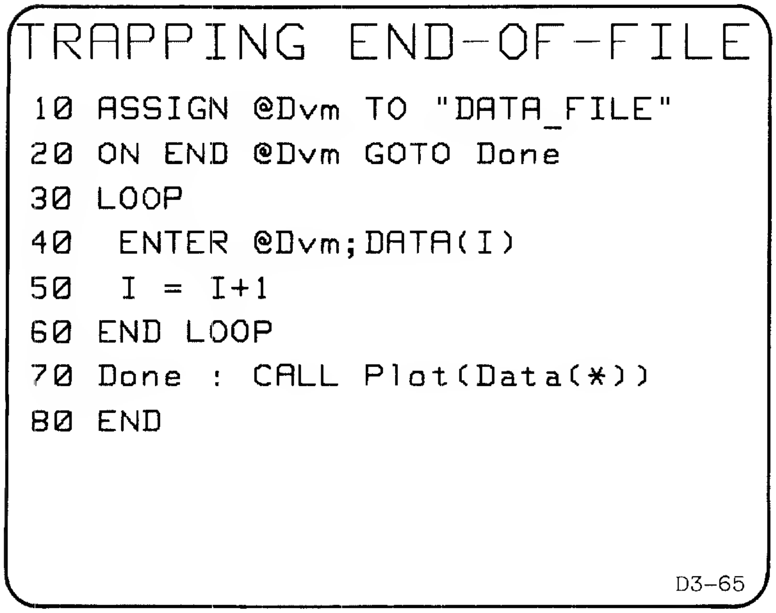


CONTRAST OF ASCII AND BDAT FILES

	ASCII	BDAT
Transportable	YES	NO
HPL Compatible	YES	NO
Serial access	YES	YES
Directed access	NO	YES
FORMAT ON	YES	YES
FORMAT OFF	NO	YES
Record length	256	Defined
Use IMAGE?	NO	YES

D3-64

NOTES



TRAPPING END-OF-FILE

```
10 ASSIGN @Dvm TO "DATA_FILE"
20 ON END @Dvm GOTO Done
30 LOOP
40  ENTER @Dvm;DATA(I)
50  I = I+1
60 END LOOP
70 Done : CALL Plot(Data(*))
80 END
```

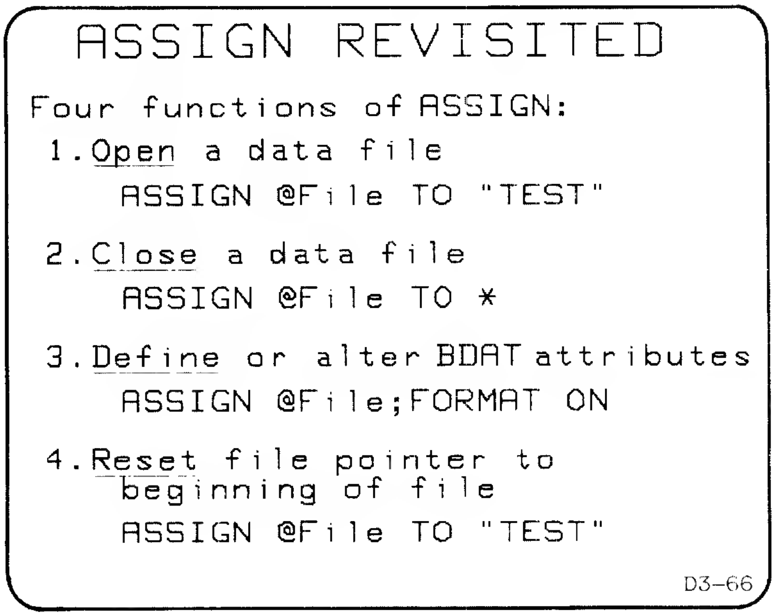
D3-65

NOTES

EXERCISE 20

Modify the program "RAND_UPDT" to use ON END and LOOP rather than the FOR-NEXT loop to read in the data. Check your solution by running the program, but you needn't bother updating any data items (enter a 0 record number).

NOTES

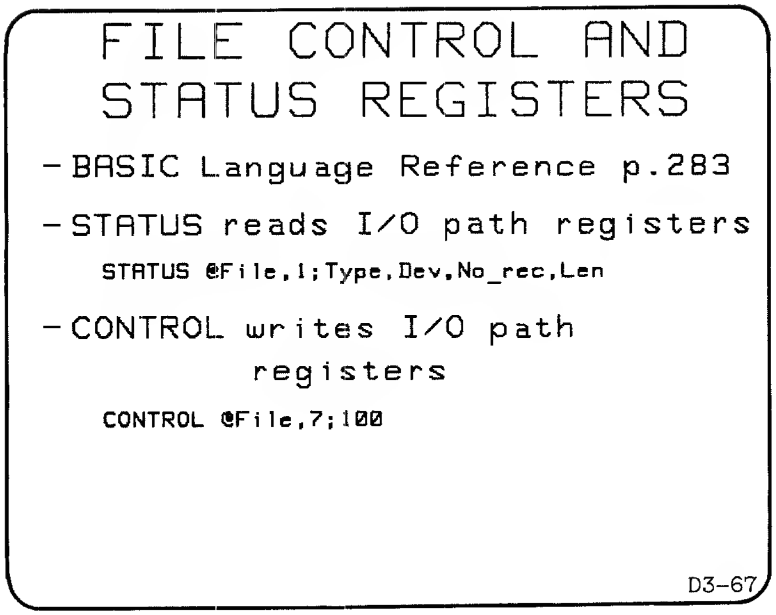


ASSIGN REVISITED

Four functions of ASSIGN:

1. Open a data file
```
ASSIGN @File TO "TEST"
```
2. Close a data file
```
ASSIGN @File TO *
```
3. Define or alter BDAT attributes
```
ASSIGN @File;FORMAT ON
```
4. Reset file pointer to beginning of file
```
ASSIGN @File TO "TEST"
```

D3-66



FILE CONTROL AND STATUS REGISTERS

- BASIC Language Reference p.283
- STATUS reads I/O path registers

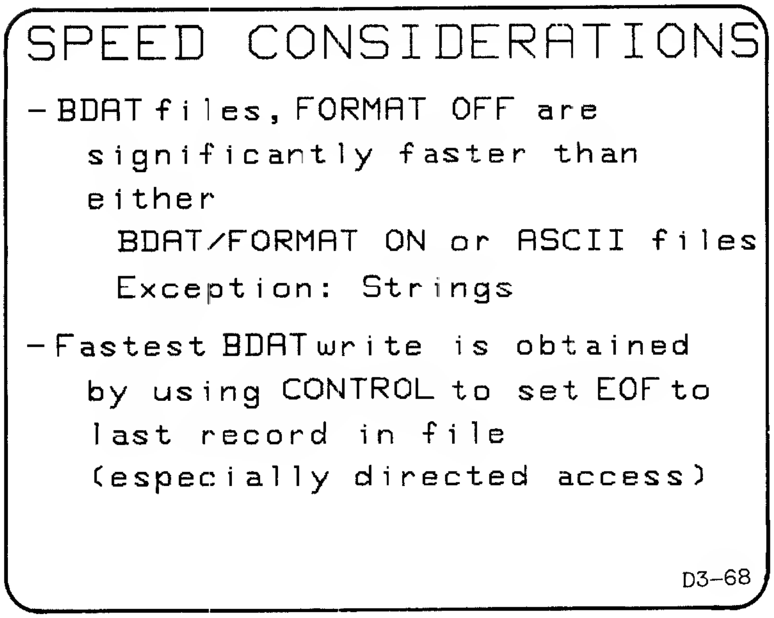
```
STATUS @File,1;Type,Dev,No_rec,Len
```

- CONTROL writes I/O path registers

```
CONTROL @File,7;100
```

D3-67

NOTES



SPEED CONSIDERATIONS

- BDAT files, FORMAT OFF are significantly faster than either
  BDAT/FORMAT ON or ASCII files
  Exception: Strings
- Fastest BDAT write is obtained by using CONTROL to set EOF to last record in file (especially directed access)

D3-68

NOTES

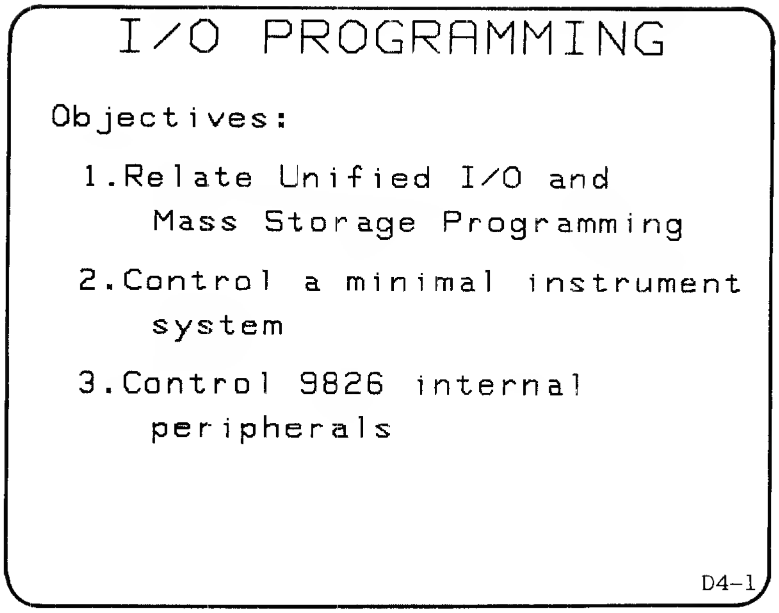
EXERCISE 21

GET "SPEED" and run the program. The program records numeric data on a BDAT file using various combinations of FORMAT ON/OFF, writing the entire array vs one element at a time, and forcing EOF to the end of file.

Analyze the printed results.

Are the relative performances what you expected? What other factors influence this application? (File size, updatability...)

1. Can you explain why Number 1 is faster than Number 3?
2. How is Number 4 so much faster than Number 2?
3. Contrast Number 5 with Number 1. Does the fewer number of bytes transferred explain the speed difference? How about formatting time?
4. Why is Number 6 only slightly faster than number 2, even though only half as many bytes are being transferred?



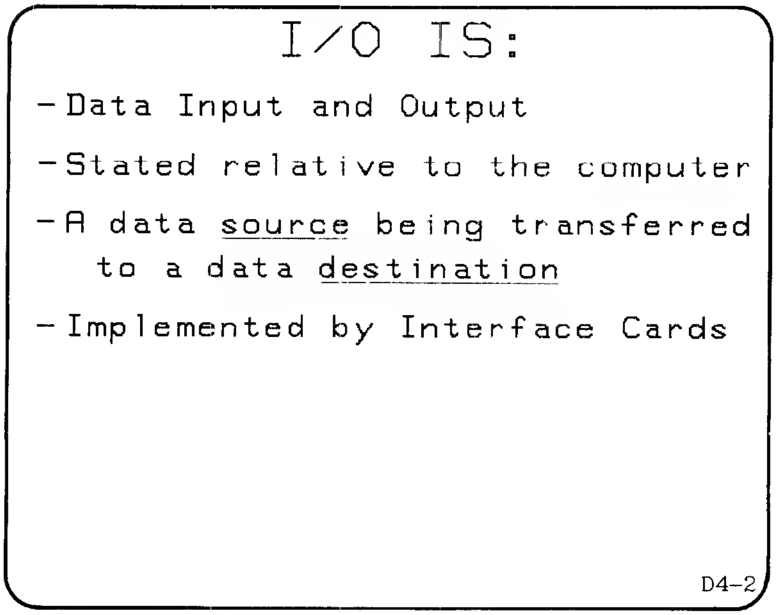
I/O PROGRAMMING

Objectives:

1. Relate Unified I/O and Mass Storage Programming
2. Control a minimal instrument system
3. Control 9826 internal peripherals

D4-1

NOTES



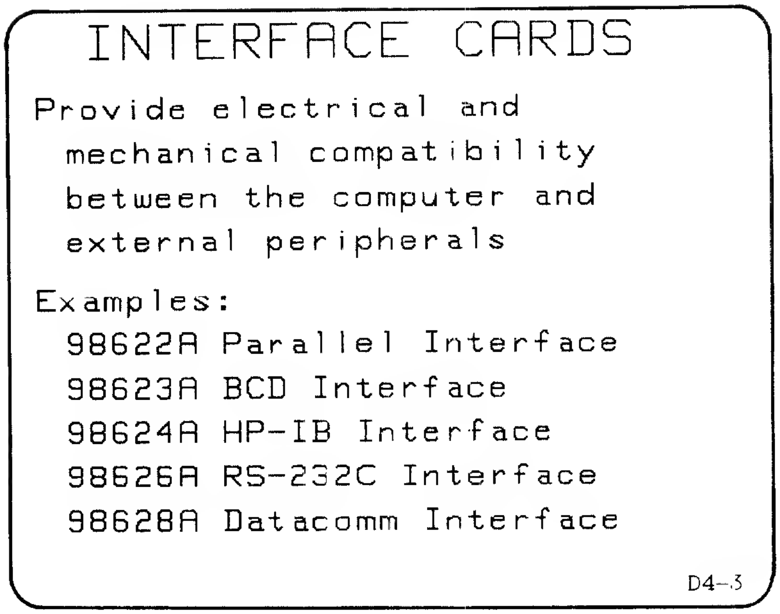
I/O IS:

- Data Input and Output
- Stated relative to the computer
- A data source being transferred to a data destination
- Implemented by Interface Cards

D4-2

NOTES

NOTES



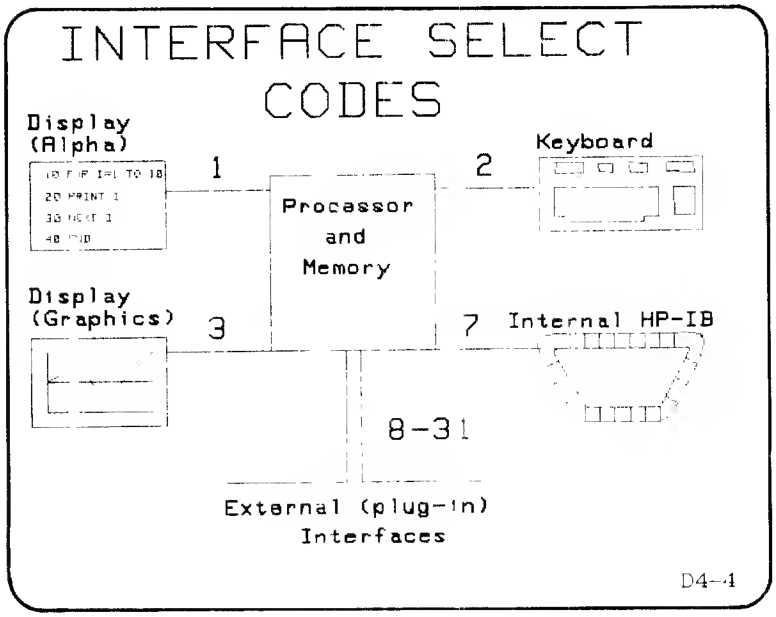
INTERFACE CARDS

Provide electrical and mechanical compatibility between the computer and external peripherals

Examples:
- 98622A Parallel Interface
- 98623A BCD Interface
- 98624A HP-IB Interface
- 98626A RS-232C Interface
- 98628A Datacomm Interface

D4-3

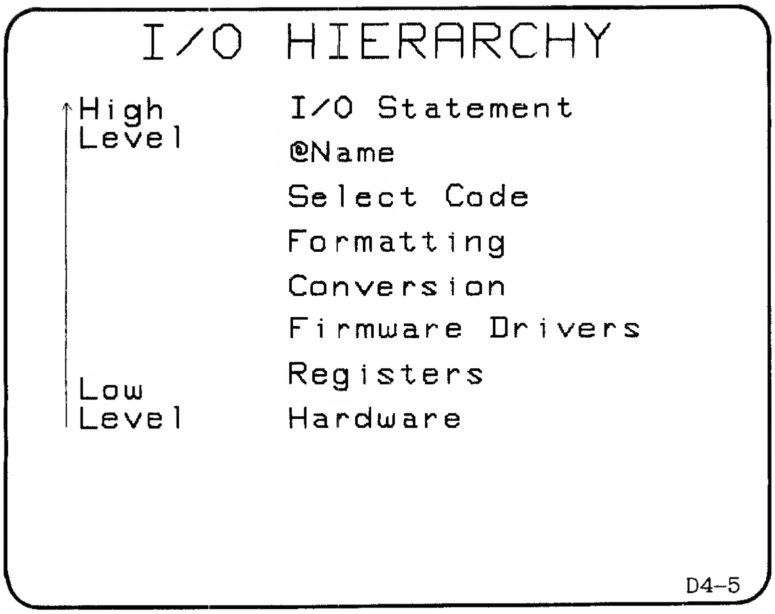
NOTES



INTERFACE SELECT CODES

```
10 FOR I=1 TO 10
20 PRINT I
30 NEXT I
40 END
```

D4-4

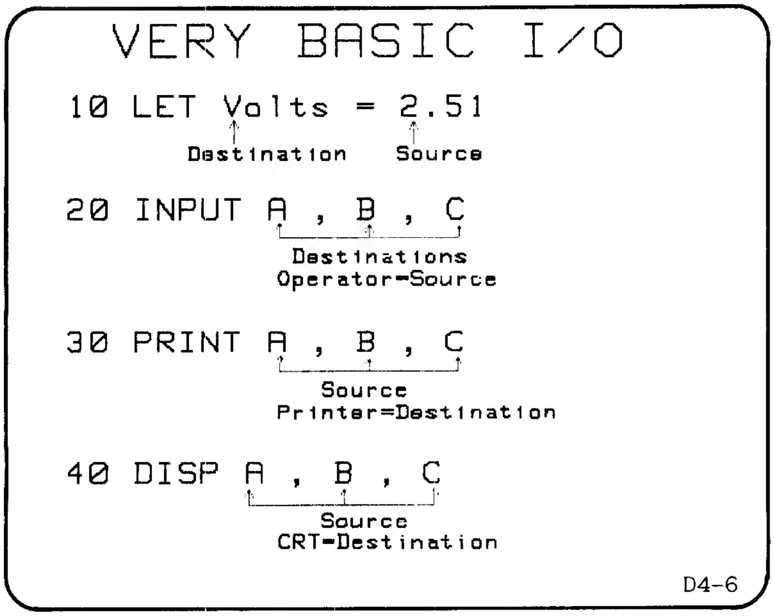


I/O HIERARCHY

↑High Level	I/O Statement
	@Name
	Select Code
	Formatting
	Conversion
	Firmware Drivers
	Registers
Low Level	Hardware

D4-5

NOTES



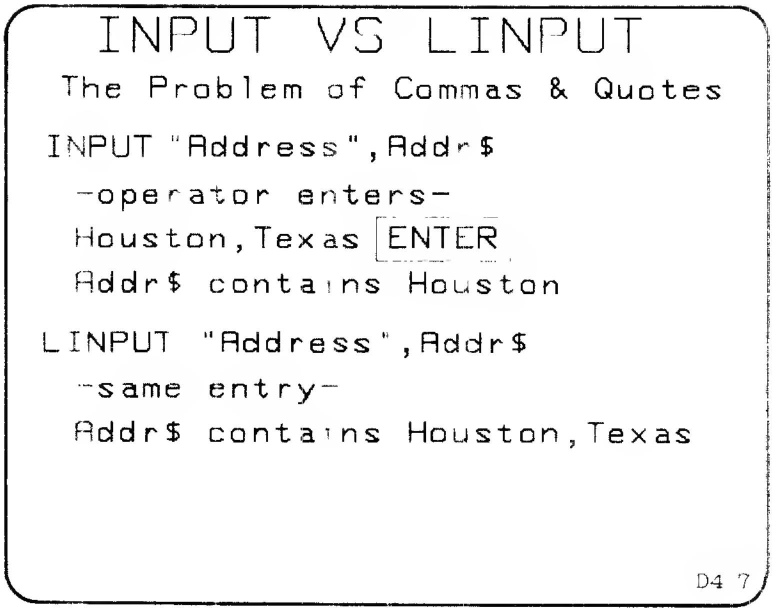
VERY BASIC I/O

```
10 LET Volts = 2.51
       ↑       ↑
  Destination  Source

20 INPUT A , B , C
         ↑   ↑   ↑
        Destinations
       Operator=Source

30 PRINT A , B , C
         ↑   ↑   ↑
           Source
       Printer=Destination

40 DISP A , B , C
        ↑   ↑   ↑
           Source
       CRT=Destination
```

D4-6

NOTES

NOTES



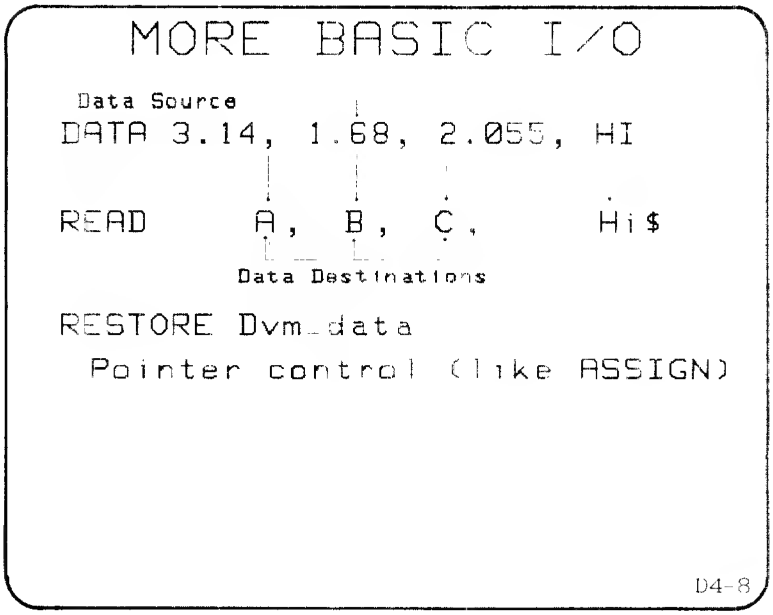
INPUT VS LINPUT

The Problem of Commas & Quotes

```
INPUT "Address",Addr$
  -operator enters-
  Houston,Texas ENTER
  Addr$ contains Houston
LINPUT "Address",Addr$
  -same entry-
  Addr$ contains Houston,Texas
```

D4 7

NOTES



MORE BASIC I/O

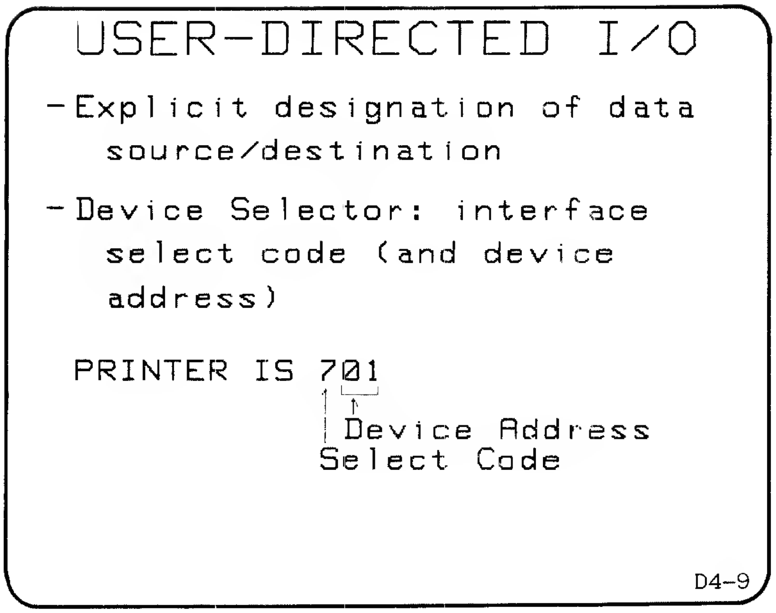
Data Source

```
DATA 3.14, 1.68, 2.055, HI

READ      A,  B,  C,      Hi$
```

Data Destinations

```
RESTORE Dvm_data
  Pointer control (like ASSIGN)
```

D4-8



USER-DIRECTED I/O

- Explicit designation of data source/destination
- Device Selector: interface select code (and device address)

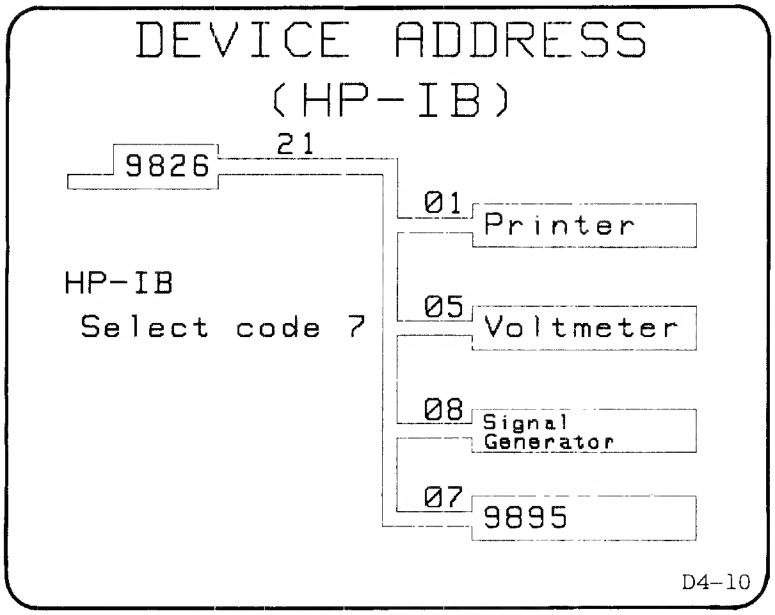
```
PRINTER IS 7Ø1
```

Device Address

Select Code

D4-9

NOTES



DEVICE ADDRESS (HP-IB)

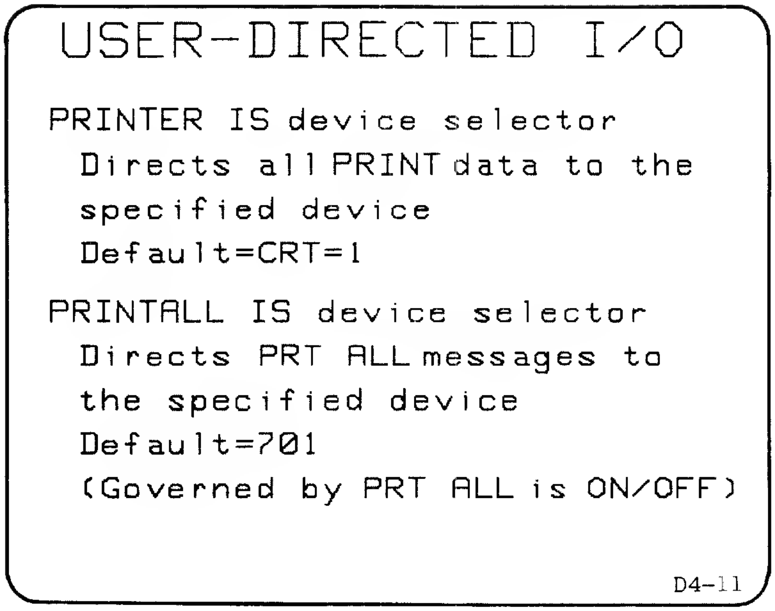
HP-IB

Select code 7

D4-10

NOTES

NOTES



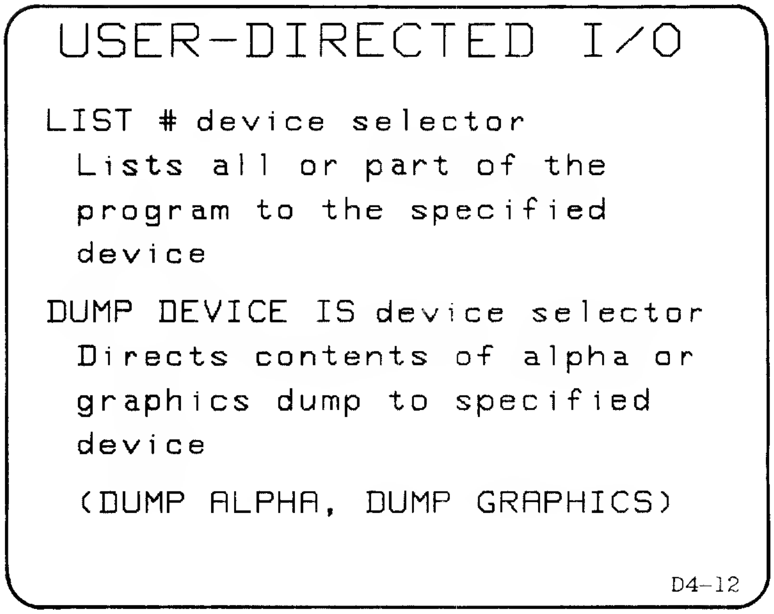
USER-DIRECTED I/O

PRINTER IS device selector
Directs all PRINT data to the specified device
Default=CRT=1

PRINTALL IS device selector
Directs PRT ALL messages to the specified device
Default=701
(Governed by PRT ALL is ON/OFF)

D4-11

NOTES



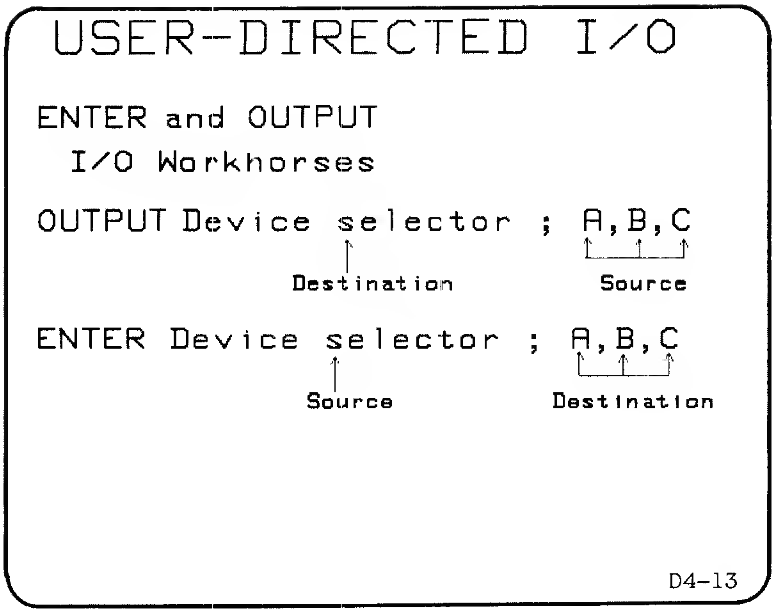
USER-DIRECTED I/O

LIST # device selector
Lists all or part of the program to the specified device

DUMP DEVICE IS device selector
Directs contents of alpha or graphics dump to specified device

(DUMP ALPHA, DUMP GRAPHICS)

D4-12



USER-DIRECTED I/O

ENTER and OUTPUT

I/O Workhorses

```
OUTPUT Device selector ; A,B,C
```

Destination

Source

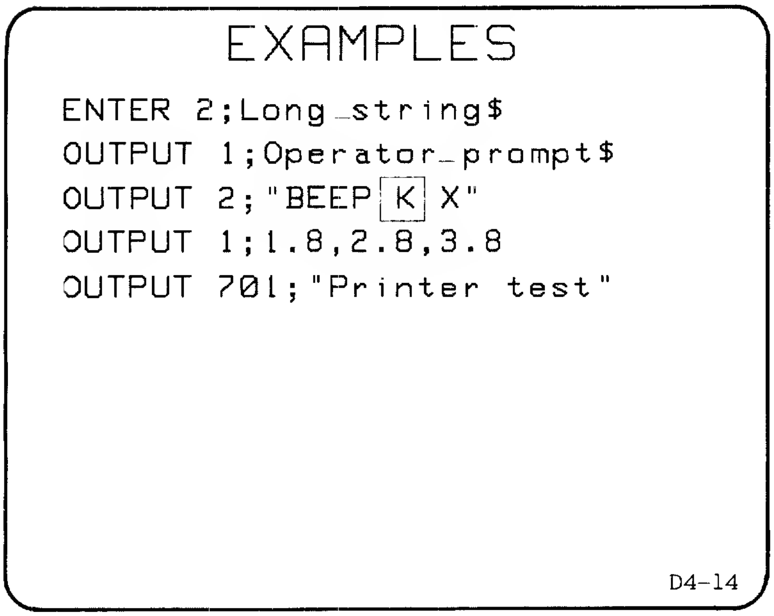
```
ENTER Device selector ; A,B,C
```

Source

Destination

D4-13

NOTES



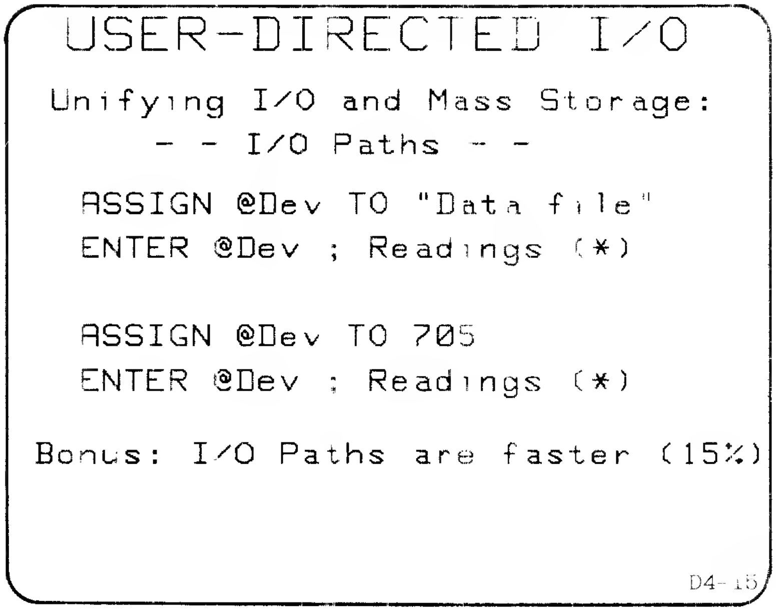
EXAMPLES

```
ENTER 2;Long_string$
OUTPUT 1;Operator_prompt$
OUTPUT 2;"BEEP K X"
OUTPUT 1;1.8,2.8,3.8
OUTPUT 701;"Printer test"
```

D4-14

NOTES

NOTES



USER-DIRECTED I/O

Unifying I/O and Mass Storage:
- - I/O Paths - -

```
ASSIGN @Dev TO "Data file"
ENTER @Dev ; Readings (*)

ASSIGN @Dev TO 705
ENTER @Dev ; Readings (*)
```

Bonus: I/O Paths are faster (15%)

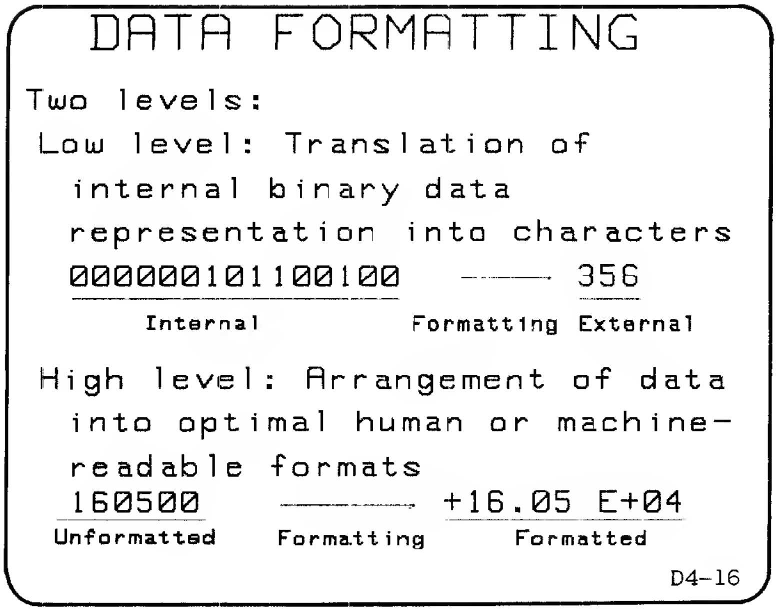
D4-15

EXERCISE 22

Write a program that takes 100 "instrument" readings and outputs those readings to the CRT, then to the printer. Your program can take the "instrument" readings off of file "SINDAT" for simulation purposes. Use only ASSIGN, OUTPUT, and ENTER to read and write the data items.

Don't forget to use the appropriate file access statement for the structure of the records on the file (sequential is 1 record of 800 bytes, directed is 100 records of 8 bytes .

Save your file as "Read_sin" (lowercase to avoid clobbering "READ_SIN").



DATA FORMATTING

Two levels:

Low level: Translation of internal binary data representation into characters

0000000101100100 ——→ 356

Internal Formatting External

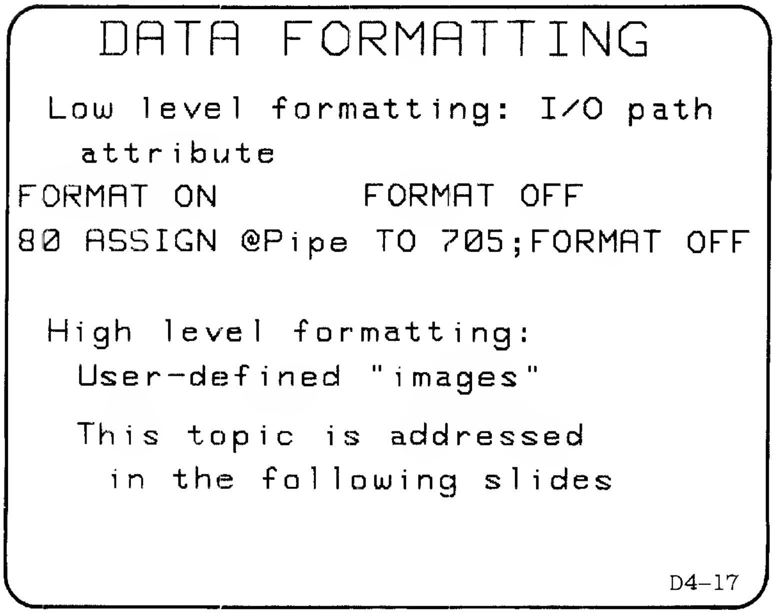
High level: Arrangement of data into optimal human or machine-readable formats

160500 ——→ +16.05 E+04

Unformatted Formatting Formatted

D4-16

NOTES



DATA FORMATTING

Low level formatting: I/O path attribute

```
FORMAT ON        FORMAT OFF
80 ASSIGN @Pipe TO 705;FORMAT OFF
```

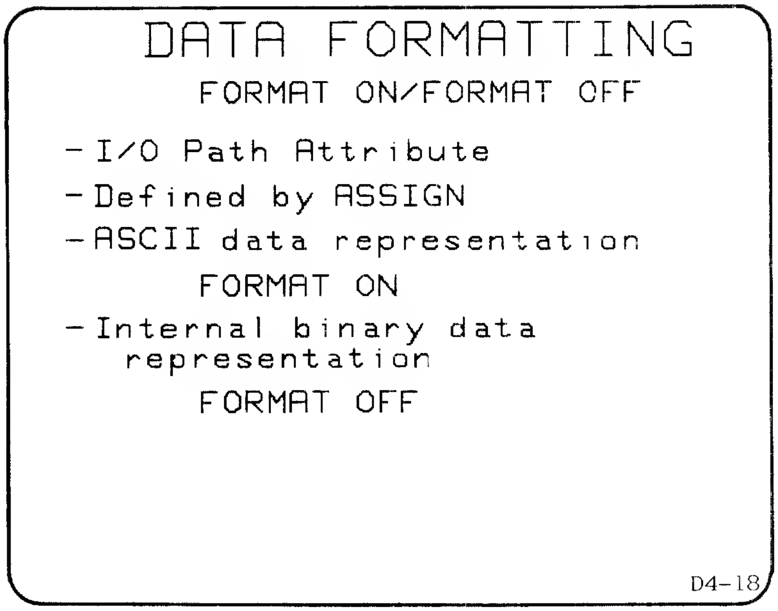
High level formatting: User-defined "images"

This topic is addressed in the following slides

D4-17

NOTES

NOTES



DATA FORMATTING

FORMAT ON/FORMAT OFF

- I/O Path Attribute
- Defined by ASSIGN
- ASCII data representation

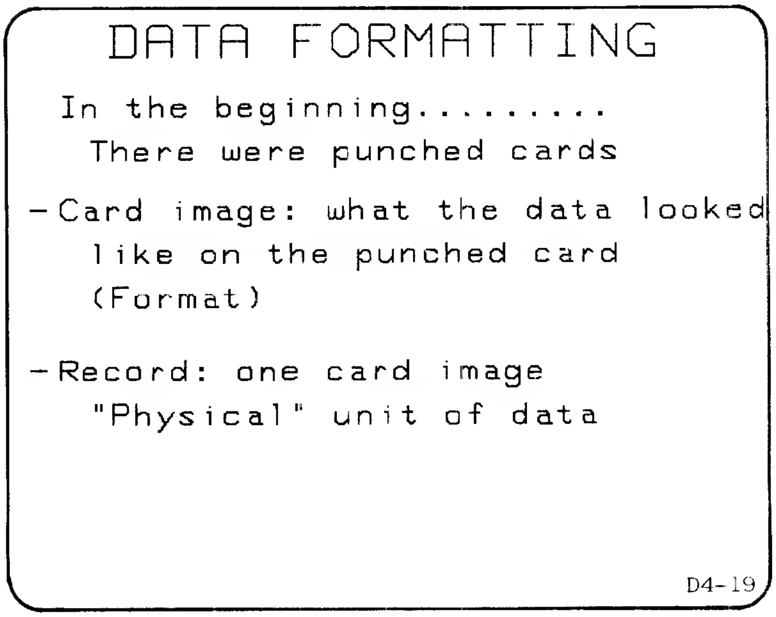
FORMAT ON

- Internal binary data representation

FORMAT OFF

D4-18

NOTES



DATA FORMATTING

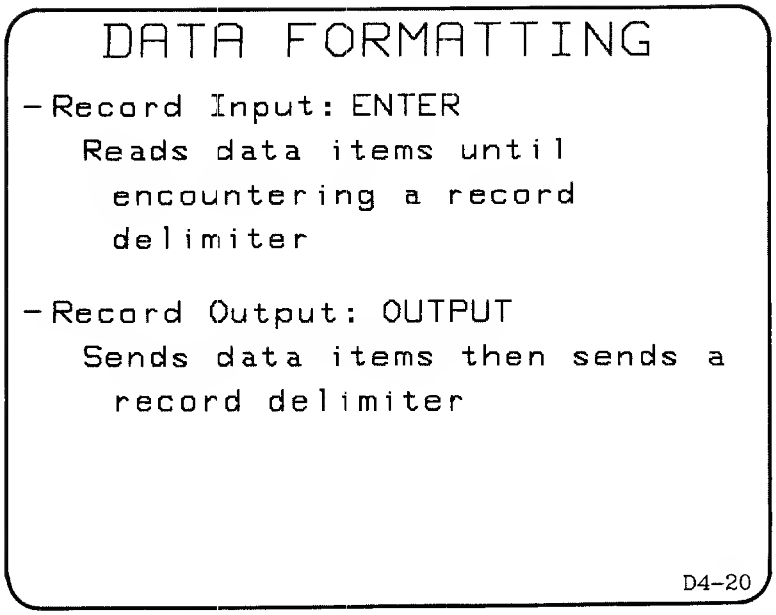
In the beginning.........

There were punched cards

- Card image: what the data looked like on the punched card (Format)

- Record: one card image "Physical" unit of data

D4-19



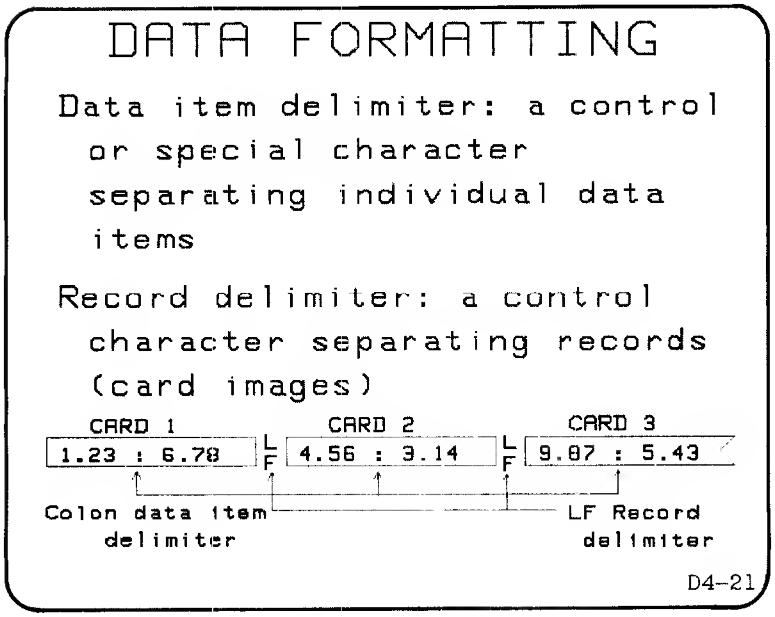
DATA FORMATTING

- Record Input: ENTER
  Reads data items until encountering a record delimiter

- Record Output: OUTPUT
  Sends data items then sends a record delimiter

D4-20

NOTES



DATA FORMATTING

Data item delimiter: a control or special character separating individual data items

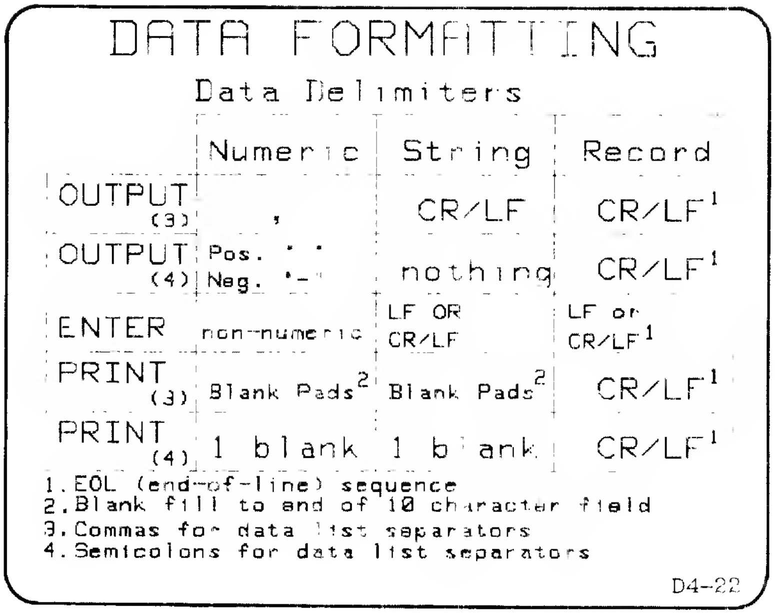
Record delimiter: a control character separating records (card images)

CARD 1
1.23 : 6.78
LF
CARD 2
4.56 : 3.14
LF
CARD 3
9.87 : 5.43
Colon data item delimiter
LF Record delimiter

D4-21

NOTES

NOTES



DATA FORMATTING

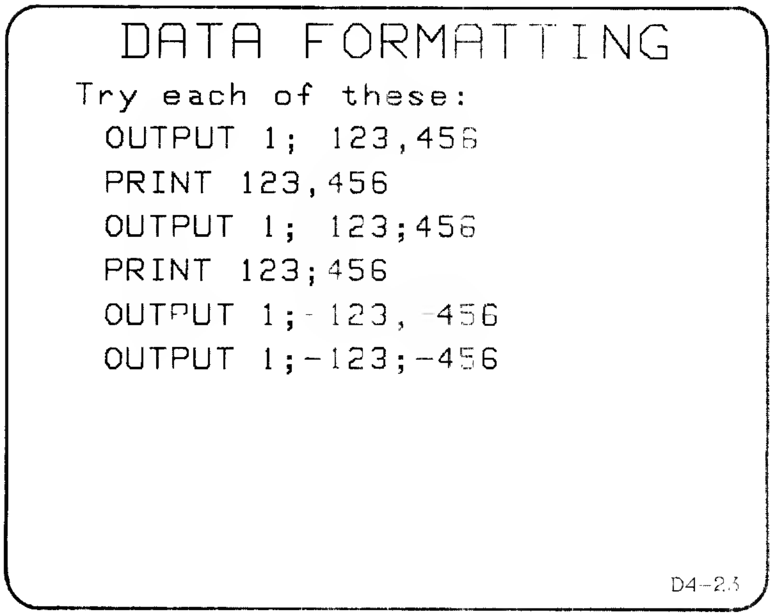
Data Delimiters

	Numeric	String	Record
OUTPUT (3)	,	CR/LF	CR/LF^1
OUTPUT (4)	Pos. " " Neg. "-"	nothing	CR/LF^1
ENTER	non-numeric	LF OR CR/LF	LF or CR/LF^1
PRINT (3)	Blank Pads^2	Blank Pads^2	CR/LF^1
PRINT (4)	1 blank	1 blank	CR/LF^1

1. EOL (end-of-line) sequence
2. Blank fill to end of 10 character field
3. Commas for data list separators
4. Semicolons for data list separators

D4-22

NOTES

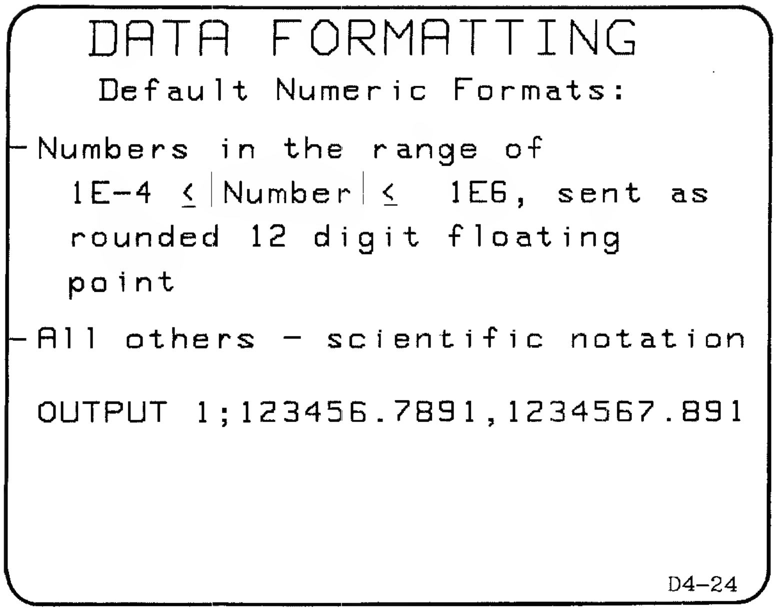


DATA FORMATTING

Try each of these:

```
OUTPUT 1; 123,456
PRINT 123,456
OUTPUT 1; 123;456
PRINT 123;456
OUTPUT 1;-123,-456
OUTPUT 1;-123;-456
```

D4-23



DATA FORMATTING

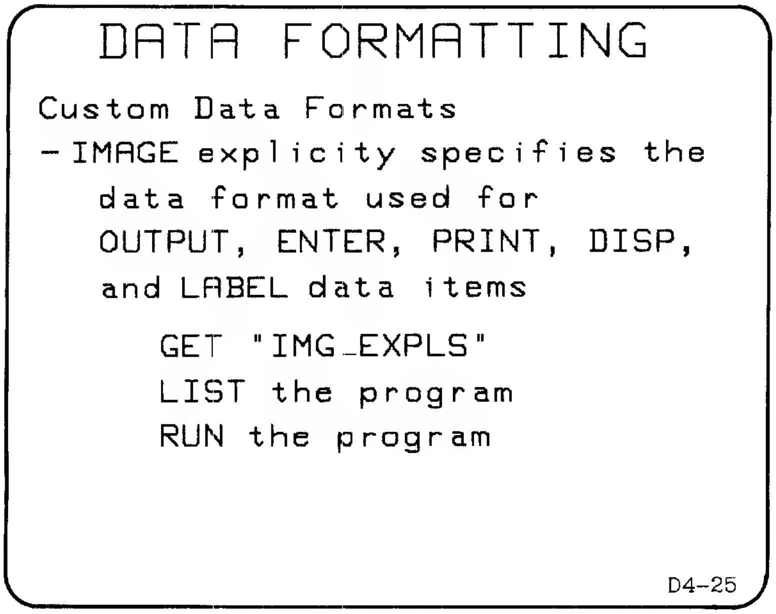
Default Numeric Formats:

- Numbers in the range of $1E-4 \leq |Number| \leq 1E6$, sent as rounded 12 digit floating point
- All others - scientific notation

```
OUTPUT 1;123456.7891,1234567.891
```

D4-24

NOTES



DATA FORMATTING

Custom Data Formats

- IMAGE explicity specifies the data format used for OUTPUT, ENTER, PRINT, DISP, and LABEL data items

```
GET "IMG_EXPLS"
LIST the program
RUN the program
```

D4-25

NOTES

NOTES

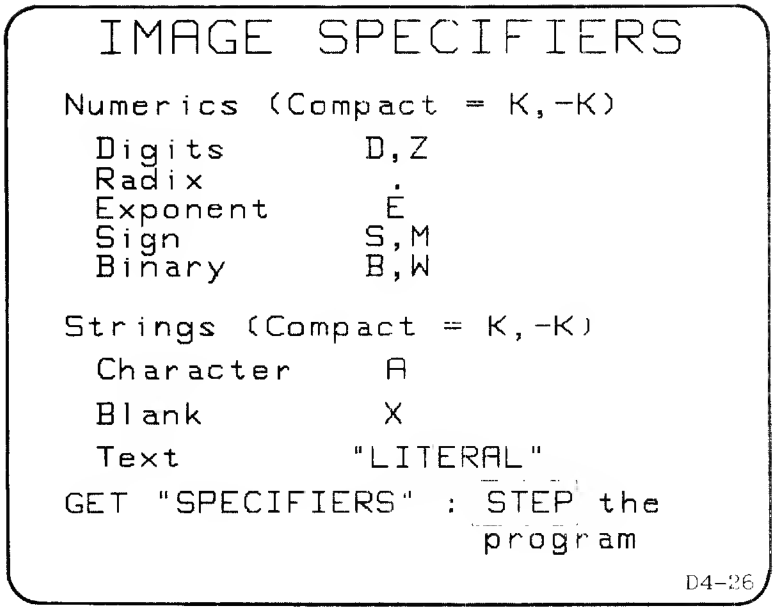


IMAGE SPECIFIERS

Numerics (Compact = K,-K)

Digits	D,Z
Radix	.
Exponent	E
Sign	S,M
Binary	B,W

Strings (Compact = K,-K)

Character	A
Blank	X
Text	"LITERAL"

GET "SPECIFIERS" : STEP the program

D4-26

NOTES

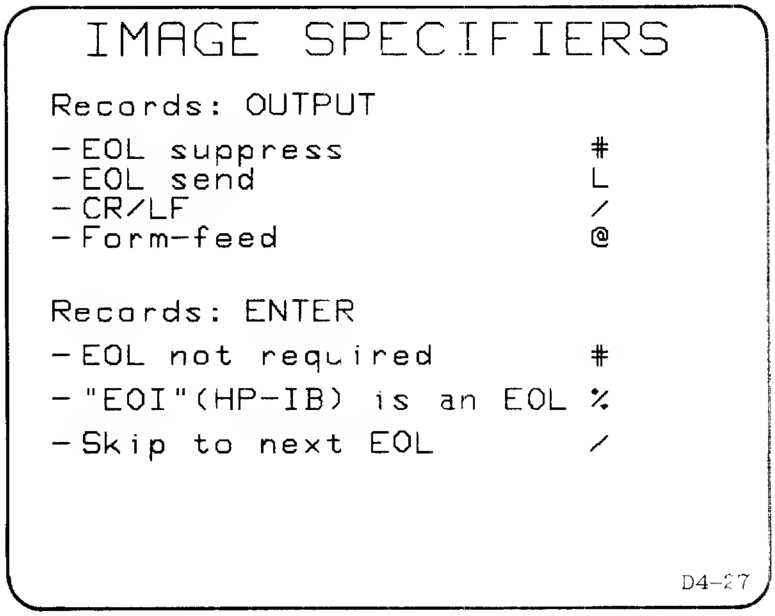


IMAGE SPECIFIERS

Records: OUTPUT

-EOL suppress	#
-EOL send	L
-CR/LF	/
-Form-feed	@

Records: ENTER

-EOL not required	#
-"EOI"(HP-IB) is an EOL	%
-Skip to next EOL	/

D4-27

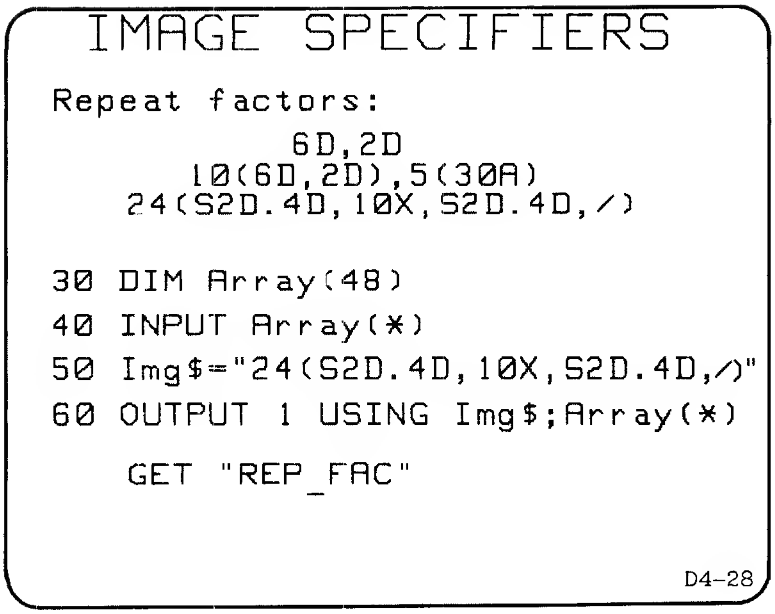


IMAGE SPECIFIERS

Repeat factors:

```
             6D,2D
        10(6D,2D),5(30A)
     24(S2D.4D,10X,S2D.4D,/)

30 DIM Array(48)
40 INPUT Array(*)
50 Img$="24(S2D.4D,10X,S2D.4D,/)"
60 OUTPUT 1 USING Img$;Array(*)

     GET "REP_FAC"
```

D4-28

EXERCISE 23

Modify program "READ_SIN" (or your program "Read_sin") to write the data items as a 5 column printout to the CRT, and a 10 column printout to the printer. Some things to be aware of:

1. You won't need an exponent.
2. Allow two digits to the left of the decimal point.
3. Three digits to the right of the decimal point are plenty (our DVM has limited accuracy).
4. Add some extra spaces between numbers on a line.
5. Remember to specify an EOL sequence with each line.

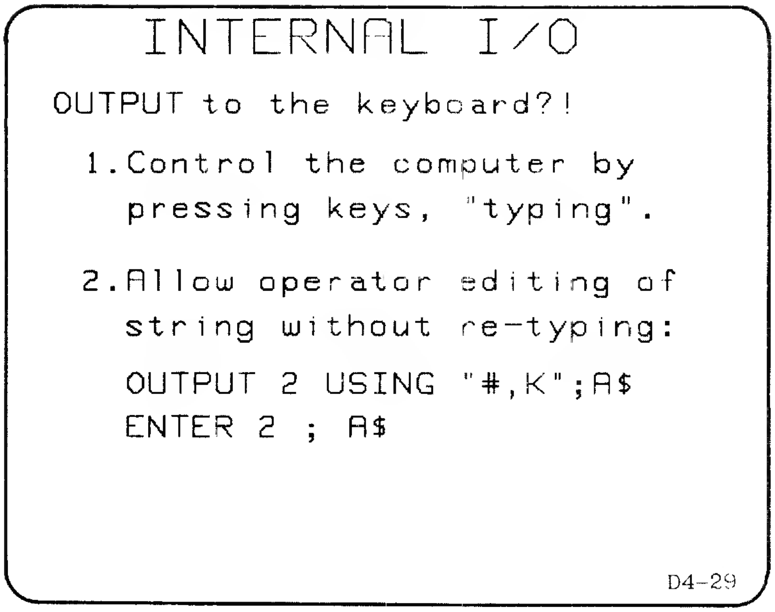
Picture one line of printout and the data images on it, then try to construct an IMAGE that will produce it.

For example:

```
-1.345      2.843      8.152      6.001      .055
```

Then add a repeat factor that will produce the desired number of lines of that format.

NOTES



INTERNAL I/O

OUTPUT to the keyboard?!

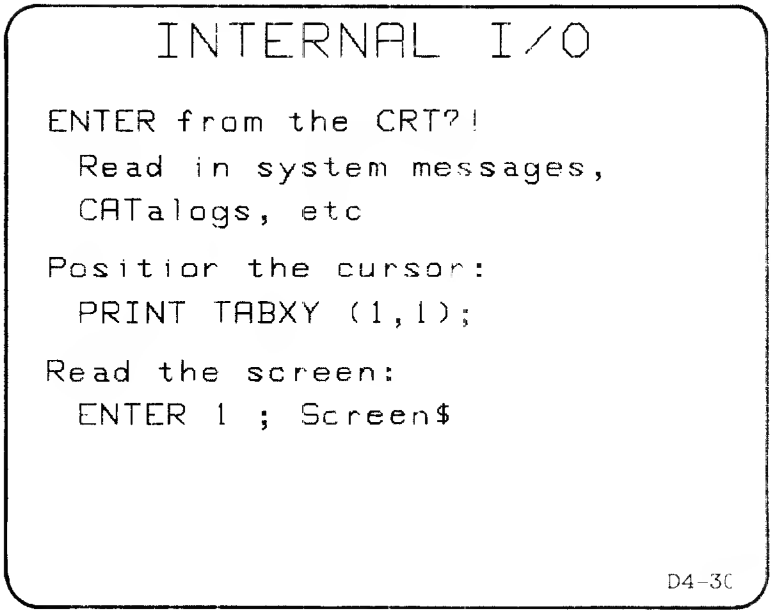
1. Control the computer by pressing keys, "typing".

2. Allow operator editing of string without re-typing:

```
OUTPUT 2 USING "#,K";A$
ENTER 2 ; A$
```

D4-29

NOTES



INTERNAL I/O

ENTER from the CRT?!

Read in system messages, CATalogs, etc

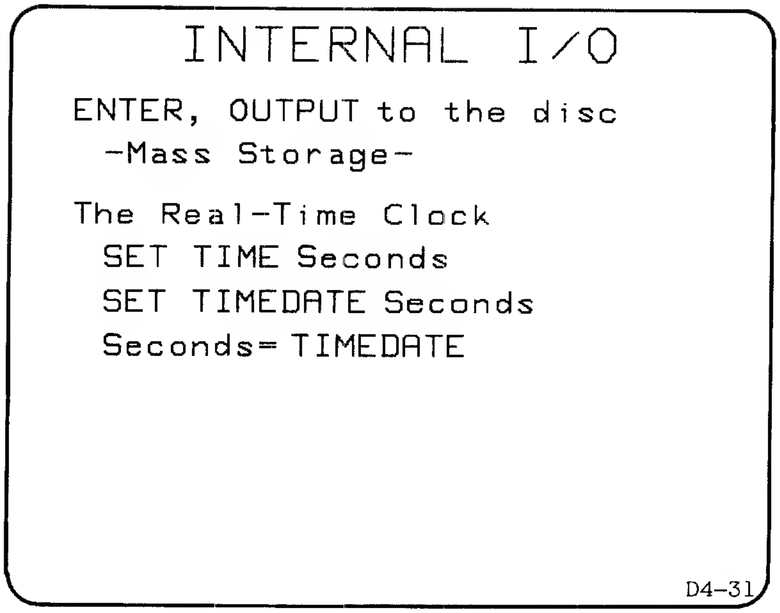
Position the cursor:

```
PRINT TABXY (1,1);
```

Read the screen:

```
ENTER 1 ; Screen$
```

D4-30



INTERNAL I/O

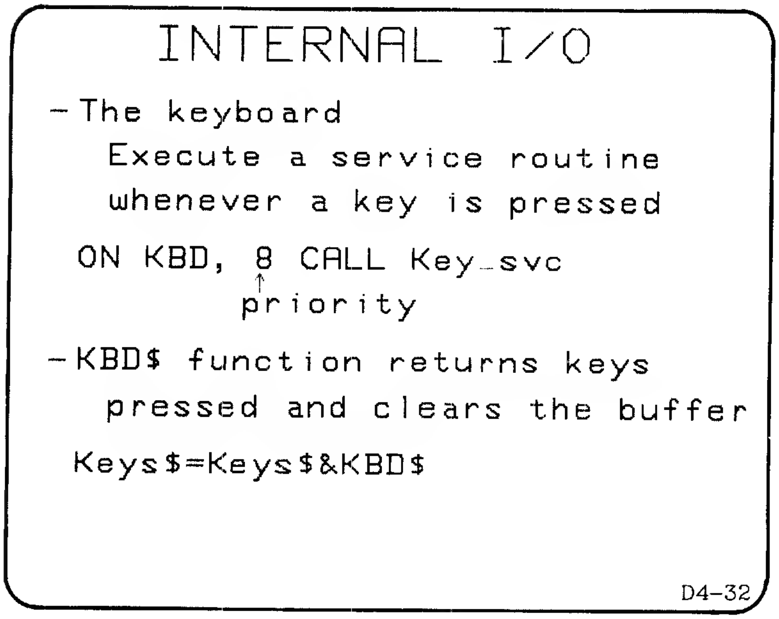
ENTER, OUTPUT to the disc
-Mass Storage-

The Real-Time Clock

```
SET TIME Seconds
SET TIMEDATE Seconds
Seconds= TIMEDATE
```

D4-31

NOTES



INTERNAL I/O

- The keyboard
  Execute a service routine whenever a key is pressed

```
ON KBD, 8 CALL Key_svc
        ↑
       priority
```

- KBD$ function returns keys pressed and clears the buffer

```
Keys$=Keys$&KBD$
```

D4-32

NOTES

EXERCISE 24

Write a program that uses ON KBD to trap keypresses and display the character and its numeric value for the pressed key. Try adding features to disable the STOP and PAUSE key functions. Look up in the Language Reference manual the function of the following statement:

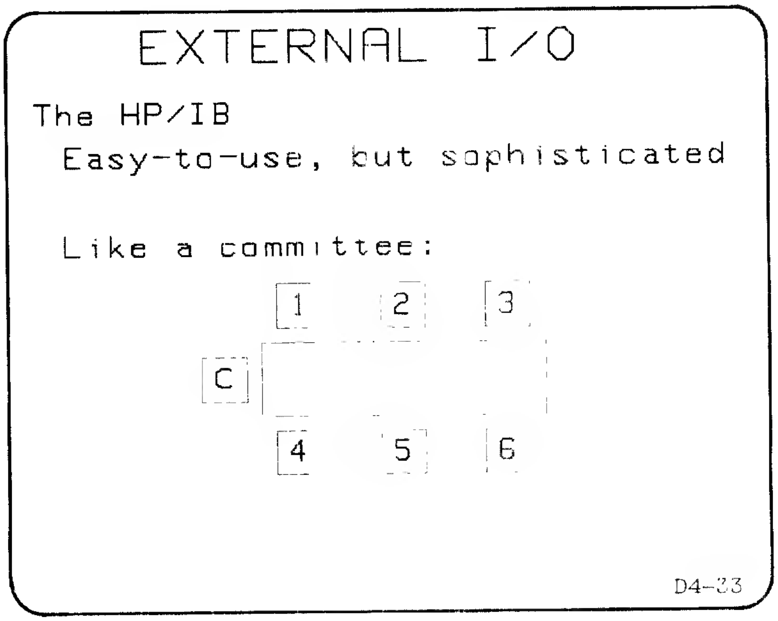
```
CONTROL 2 , 7 ; 2
```

(Hint - look at the "Keyboard Status and Control Registers" table in the back of the manual.)

What effect would this statement have on the operator and the program? How might an operator stop the program if necessary? Perhaps a sequence of Control-Shift-Key(X) to signal an extraordinary condition to the program?

Use CTRL - SHIFT - STEP - to stop "ON_KBD" after you run it.

NOTES



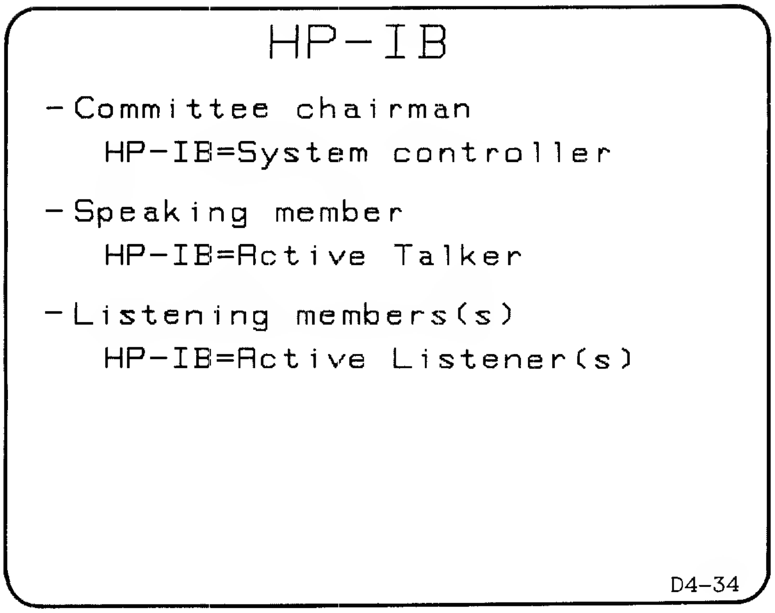
EXTERNAL I/O

The HP/IB

Easy-to-use, but sophisticated

Like a committee:

D4-33

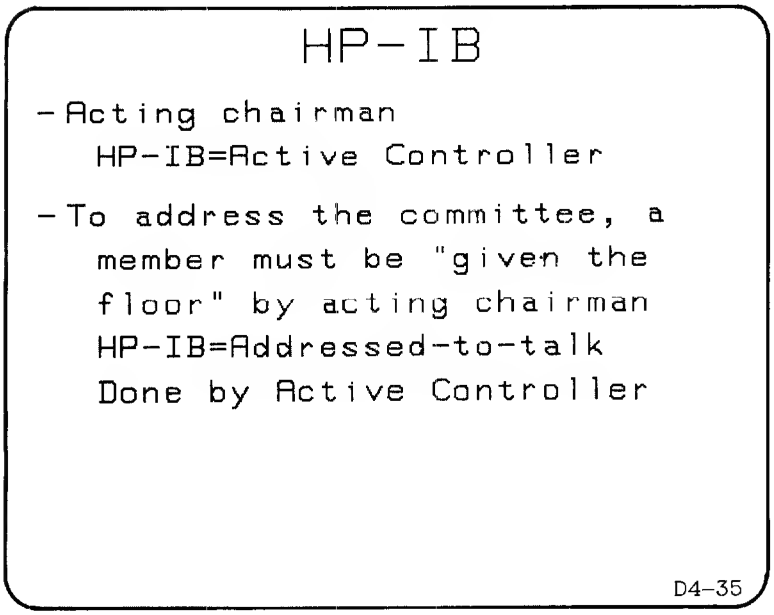


HP-IB

- Committee chairman
  HP-IB=System controller
- Speaking member
  HP-IB=Active Talker
- Listening members(s)
  HP-IB=Active Listener(s)

D4-34

NOTES



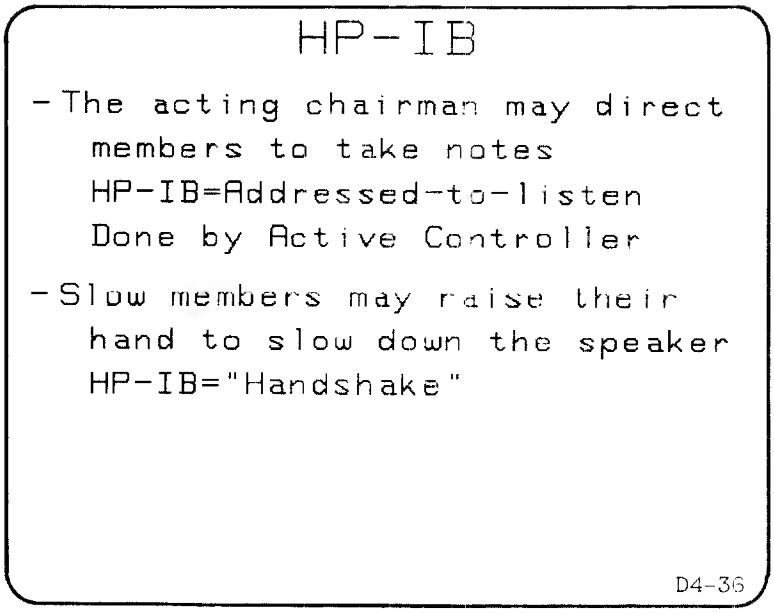
HP-IB

- Acting chairman
  HP-IB=Active Controller
- To address the committee, a
  member must be "given the
  floor" by acting chairman
  HP-IB=Addressed-to-talk
  Done by Active Controller

D4-35

NOTES

NOTES

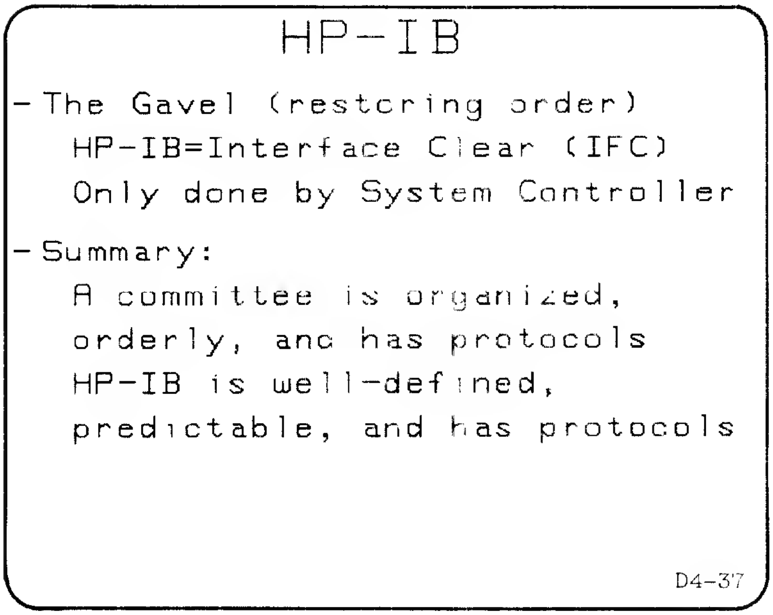


HP-IB

- The acting chairman may direct members to take notes
  HP-IB=Addressed-to-listen
  Done by Active Controller
- Slow members may raise their hand to slow down the speaker
  HP-IB="Handshake"

D4-36

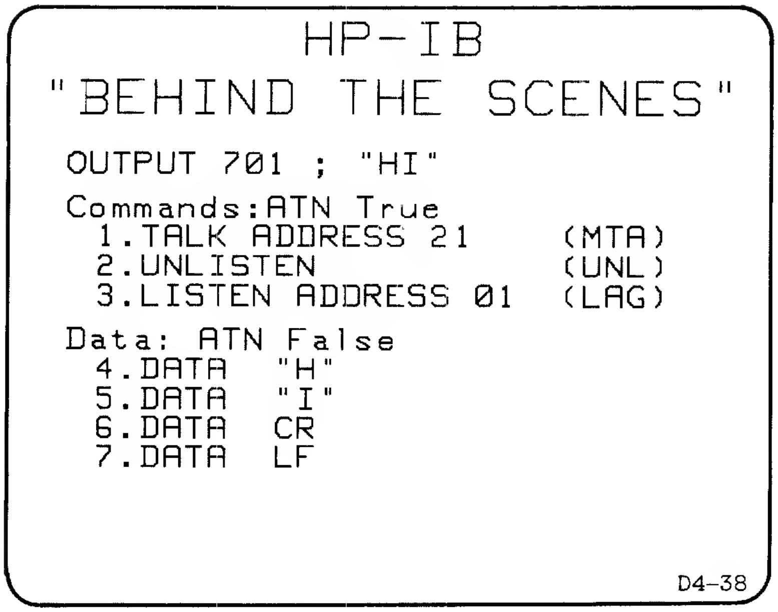
NOTES



HP-IB

- The Gavel (restoring order)
  HP-IB=Interface Clear (IFC)
  Only done by System Controller
- Summary:
  A committee is organized, orderly, and has protocols
  HP-IB is well-defined, predictable, and has protocols

D4-37

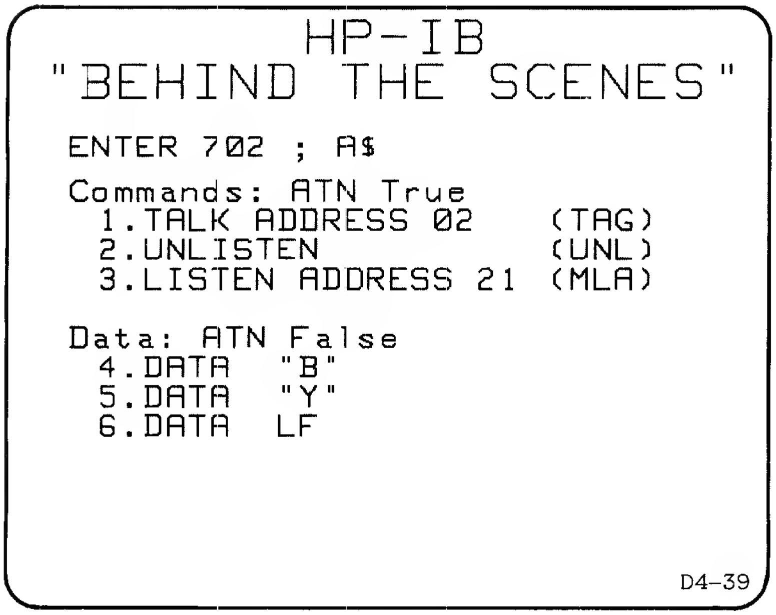


HP-IB
"BEHIND THE SCENES"

```
OUTPUT 701 ; "HI"

Commands:ATN True
  1.TALK ADDRESS 21     (MTA)
  2.UNLISTEN            (UNL)
  3.LISTEN ADDRESS 01   (LAG)

Data: ATN False
  4.DATA  "H"
  5.DATA  "I"
  6.DATA  CR
  7.DATA  LF
```

D4-38

NOTES



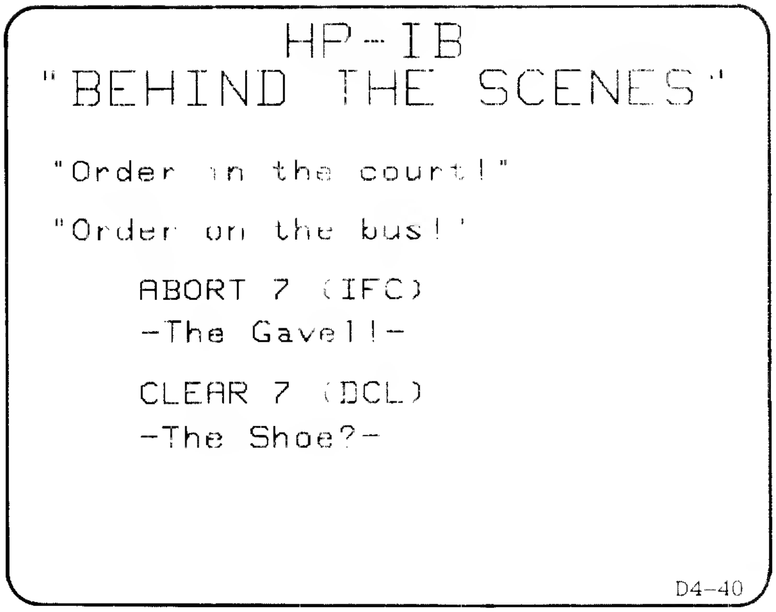
HP-IB
"BEHIND THE SCENES"

```
ENTER 702 ; A$

Commands: ATN True
  1.TALK ADDRESS 02    (TAG)
  2.UNLISTEN           (UNL)
  3.LISTEN ADDRESS 21  (MLA)

Data: ATN False
  4.DATA  "B"
  5.DATA  "Y"
  6.DATA  LF
```

D4-39

NOTES

NOTES



HP-IB
"BEHIND THE SCENES"

"Order in the court!"

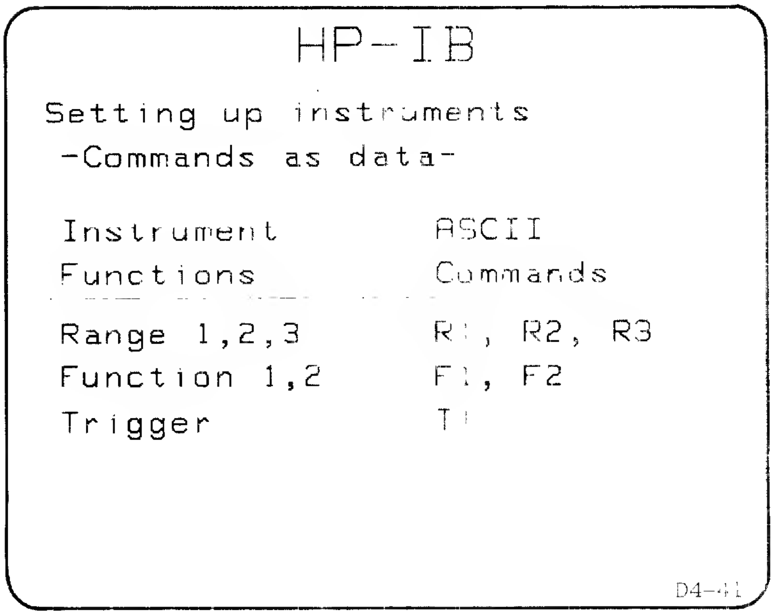
"Order on the bus!"

ABORT 7 (IFC)
-The Gavel!-

CLEAR 7 (DCL)
-The Shoe?-

D4-40

NOTES

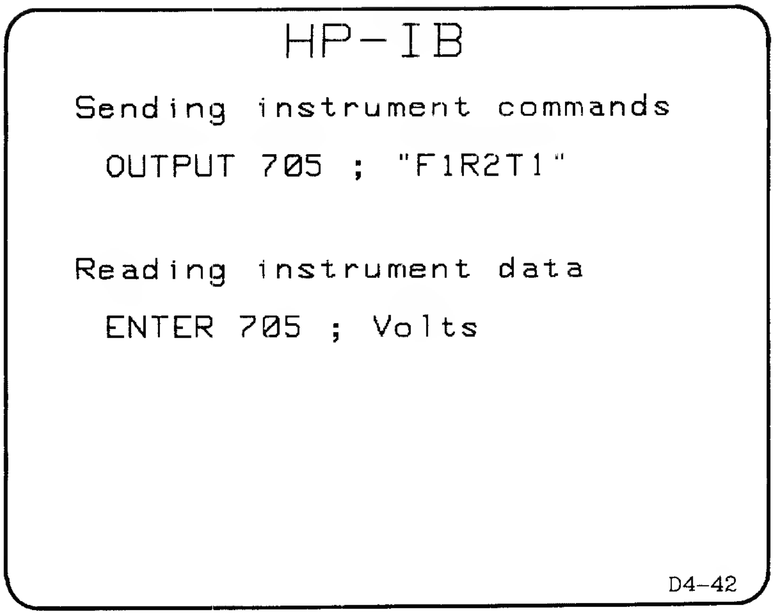


HP-IB

Setting up instruments
-Commands as data-

Instrument Functions	ASCII Commands
Range 1,2,3	R1, R2, R3
Function 1,2	F1, F2
Trigger	T1

D4-41



HP-IB

Sending instrument commands

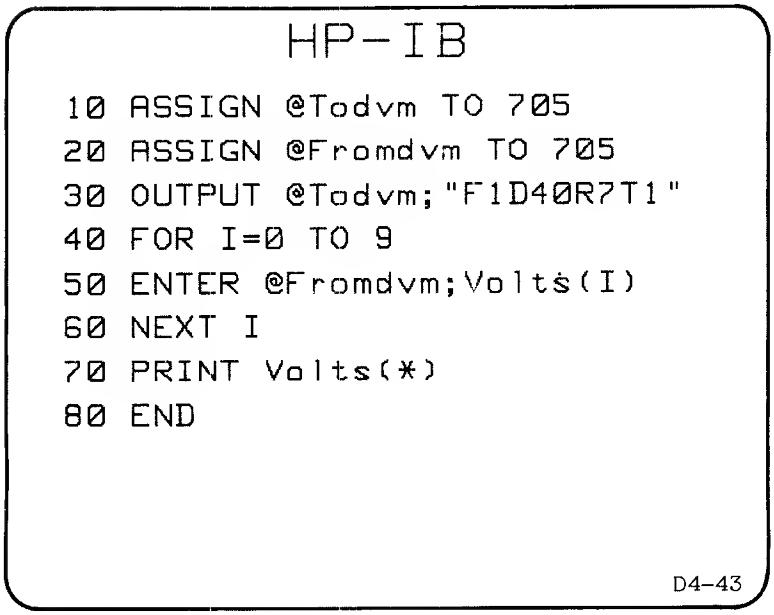
```
OUTPUT 705 ; "F1R2T1"
```

Reading instrument data

```
ENTER 705 ; Volts
```

D4-42

NOTES



HP-IB

```
10 ASSIGN @Todvm TO 705
20 ASSIGN @Fromdvm TO 705
30 OUTPUT @Todvm;"F1D40R7T1"
40 FOR I=0 TO 9
50 ENTER @Fromdvm;Volts(I)
60 NEXT I
70 PRINT Volts(*)
80 END
```

D4-43

NOTES

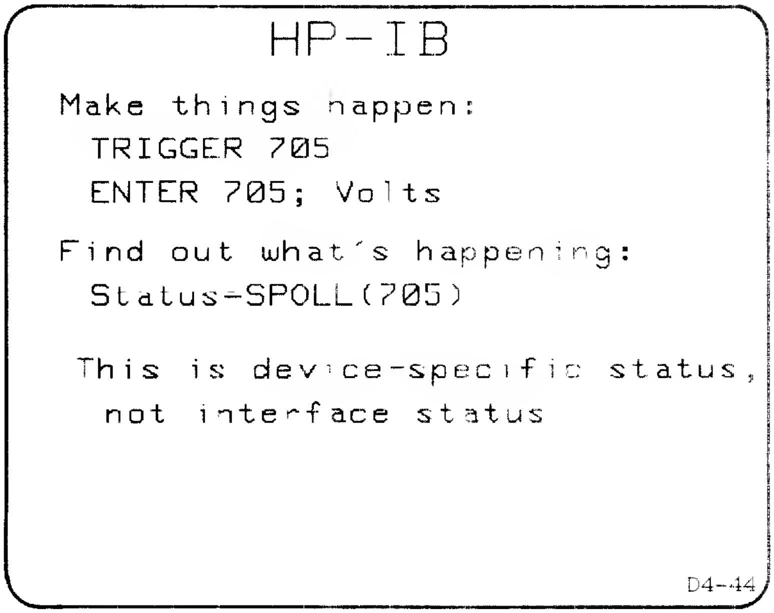
EXERCISE 25 (Optional)

Modify your program "Read_sin" or the solution program "READ_SIN" to work with a voltmeter. Take the readings from the device (instead of the file) and write them to the file, CRT, and printer.

1. You will need to insert some program lines similar to those on the previous slide to take the readings from the instrument.
2. You may need to modify the instrument commands depending on the particular set-up available to your class.
3. Output the 100 reading array back to the file "SINDAT". This should simply be a matter of changing ENTER to OUTPUT.

Note: If an instrument is not available, assign the "Todvm" I/O path to a temporary file (one record of 256 bytes is sufficient) and the "Fromdvm" I/C path to "SINDAT".

NOTES



HP-IB

Make things happen:

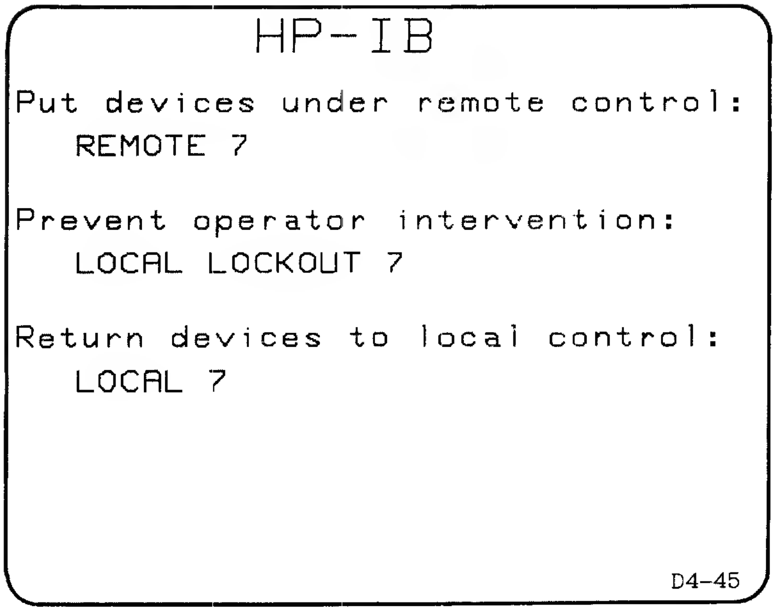
```
TRIGGER 705
ENTER 705; Volts
```

Find out what's happening:

```
Status=SPOLL(705)
```

This is device-specific status, not interface status

D4-44



HP-IB

Put devices under remote control:

```
   REMOTE 7
```

Prevent operator intervention:

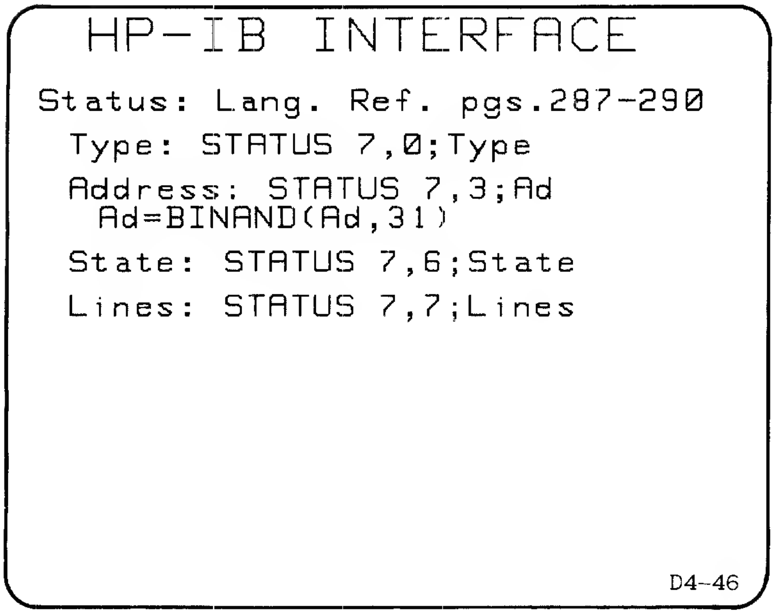
```
   LOCAL LOCKOUT 7
```

Return devices to local control:

```
   LOCAL 7
```

D4-45

NOTES



HP-IB INTERFACE

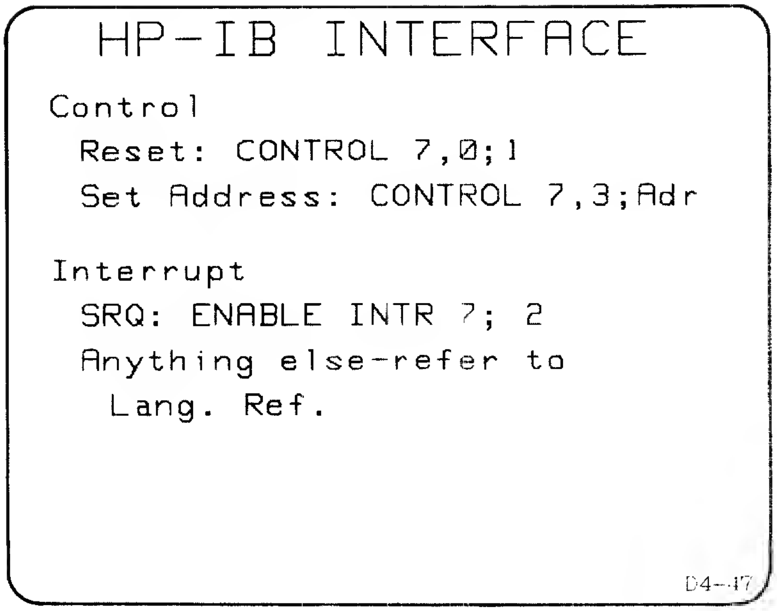
Status: Lang. Ref. pgs.287-290

```
  Type: STATUS 7,0;Type
  Address: STATUS 7,3;Ad
    Ad=BINAND(Ad,31)
  State: STATUS 7,6;State
  Lines: STATUS 7,7;Lines
```

D4-46

NOTES

NOTES



HP-IB INTERFACE

Control

Reset: CONTROL 7,Ø;1

Set Address: CONTROL 7,3;Adr

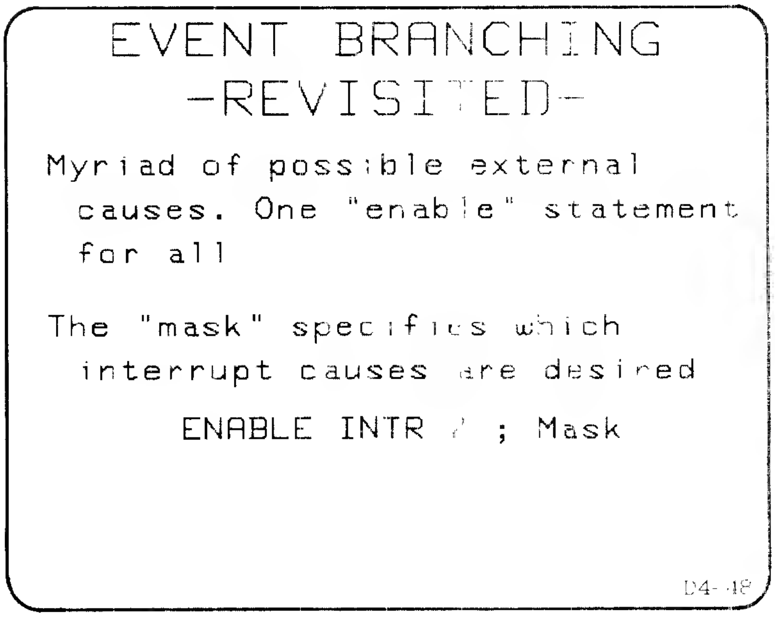
Interrupt

SRQ: ENABLE INTR 7; 2

Anything else-refer to Lang. Ref.

D4-47

NOTES



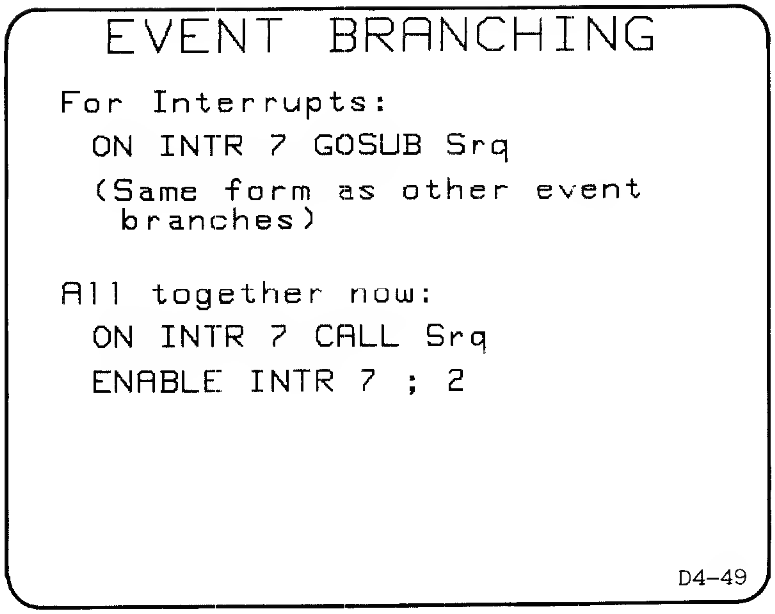
EVENT BRANCHING -REVISITED-

Myriad of possible external causes. One "enable" statement for all

The "mask" specifies which interrupt causes are desired

ENABLE INTR 7 ; Mask

D4-48



EVENT BRANCHING

For Interrupts:

```
ON INTR 7 GOSUB Srq
```

(Same form as other event branches)

All together now:

```
ON INTR 7 CALL Srq
ENABLE INTR 7 ; 2
```

D4-49

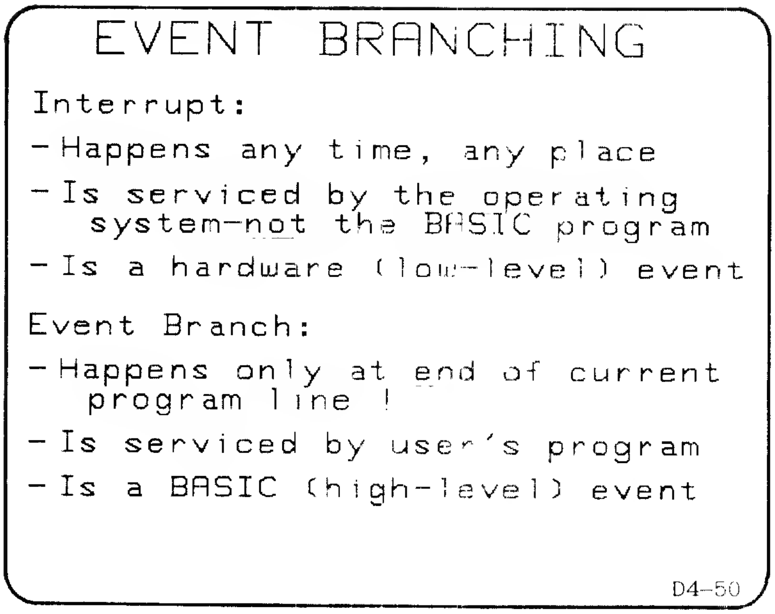
NOTES

EXERCISE 26

Write a program that enables and services a service request. The program should contain a main loop that displays a counter, and a service routine. In your service routine, obtain the device's status and print the result. (Use SPOLL).

1. To generate a service request, press the SRQ button on the HP-IB box.
2. To deal with SPOLL using the HP-IB box, you need to accept several command bytes, then when the ATN line goes false, send one response byte, then you must accept two more command bytes. At this point, SPOLL is complete.

Your program must re-execute ENABLE INTR if it is to continue servicing SRQ interrupts.



EVENT BRANCHING

Interrupt:

- Happens any time, any place
- Is serviced by the operating system-not the BASIC program
- Is a hardware (low-level) event

Event Branch:

- Happens only at end of current program line !
- Is serviced by user's program
- Is a BASIC (high-level) event

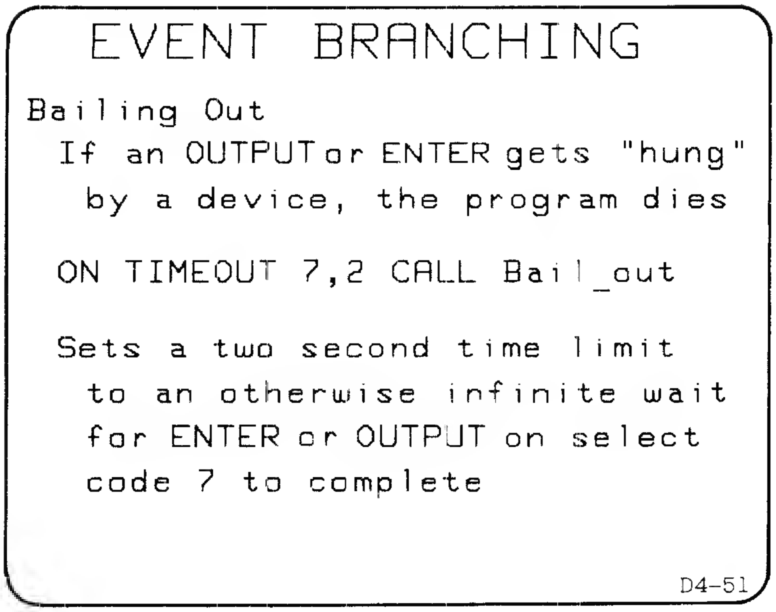
D4-50

EXERCISE 27

Modify your service-request program so that the main program is executing a WAIT 5 in the loop. Change the SPOLL function in your service routine to a PRINT "HERE" statement. Watch how long it takes your program to service the SRQ.

Try pressing SRQ twice in rapid succession. Does the service routine get executed twice? What does this mean?

What effect would this have on your programming efforts if you required a short response time to interrupts? What can happen to interrupts coming in at too high a frequency?



EVENT BRANCHING

Bailing Out

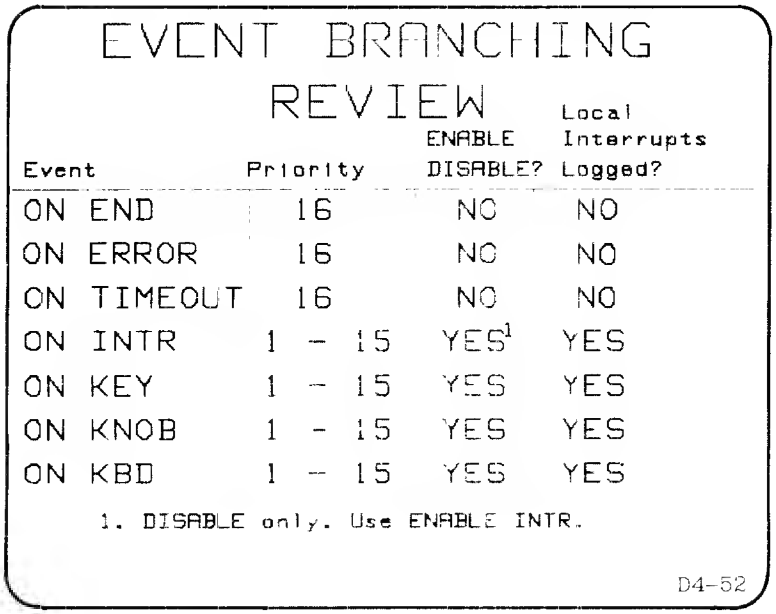
If an OUTPUT or ENTER gets "hung" by a device, the program dies

```
ON TIMEOUT 7,2 CALL Bail_out
```

Sets a two second time limit to an otherwise infinite wait for ENTER or OUTPUT on select code 7 to complete

D4-51

NOTES



EVENT BRANCHING REVIEW

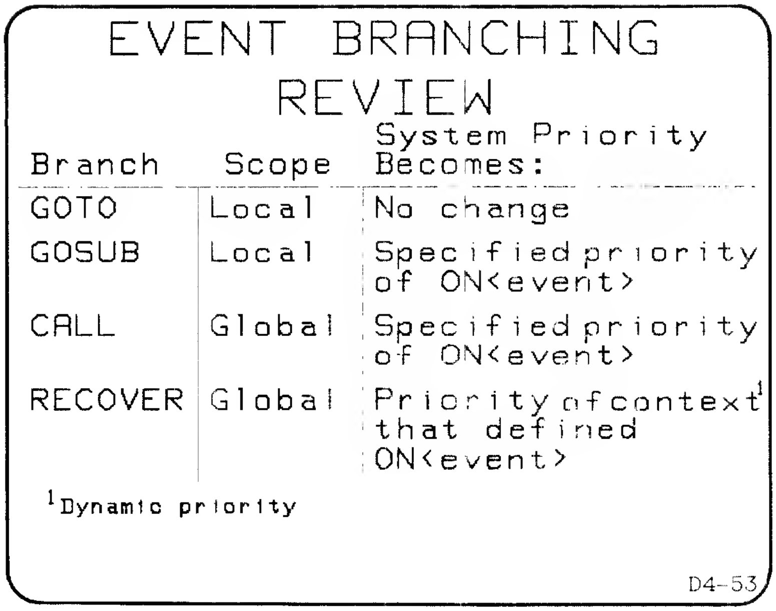
Event	Priority	ENABLE DISABLE?	Local Interrupts Logged?
ON END	16	NO	NO
ON ERROR	16	NO	NO
ON TIMEOUT	16	NO	NO
ON INTR	1 - 15	YES[1]	YES
ON KEY	1 - 15	YES	YES
ON KNOB	1 - 15	YES	YES
ON KBD	1 - 15	YES	YES

[1]. DISABLE only. Use ENABLE INTR.

D4-52

NOTES

NOTES



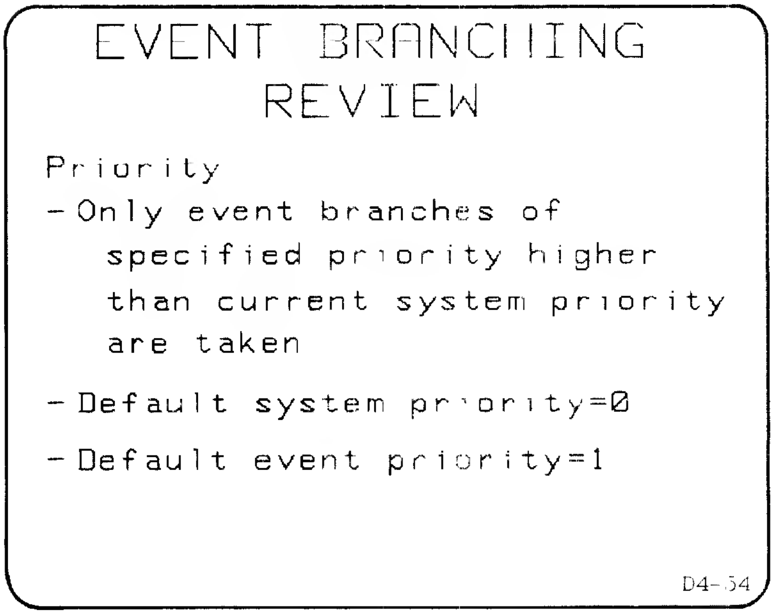
EVENT BRANCHING REVIEW

Branch	Scope	System Priority Becomes:
GOTO	Local	No change
GOSUB	Local	Specified priority of ON<event>
CALL	Global	Specified priority of ON<event>
RECOVER	Global	Priority of context[1] that defined ON<event>

[1] Dynamic priority

D4-53

NOTES



EVENT BRANCHING REVIEW

Priority

- Only event branches of specified priority higher than current system priority are taken
- Default system priority=0
- Default event priority=1

D4-54

EXERCISE 28

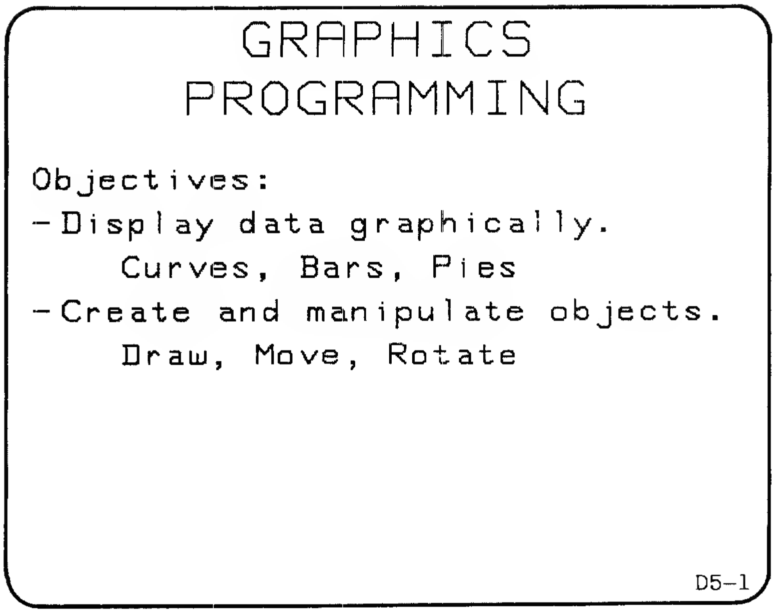
Write a program with service routines for errors, special function keys, the knob, and external (SRQ) interrupts. Define priorities and branch types to ensure that SRQ is always serviced immediately, regardless of current program context.

1. K1, K2, and K3 invoke subroutines of priority levels 1, 2, and 3 respectively, and display operating priority.
2. K 19 is an "abort" key that returns program execution to the main program loop - inspite of current context and operating conditions.
3. The knob causes all but SRQ service to be disabled for the duration of knob service then reenabled at the end of the routine.
4. An error has the same effect as pressing K 19.

In each service routine, display the current priority, the routine's name and a counter that is incremented to 500 before exiting the routine.

Try various combinations of knob rotation, keypresses, and SRQ to determine if the logic of your program is correct. Be sure that SRQ is always serviced, regardless of what the computer is doing.

After your program is running correctly, add a subprogram that displays the current nesting level (how many times it has called itself), increments the nesting level counter, allocates a 100 element array, waits for .05 seconds, then calls itself. Add a call to this subprogram in the main program and run your program again. Which interrupts will get serviced? Which won't? How many levels of nesting do you get before you get an error? (How can you tell you got an error?) What happens if you press K19 before then? Try pressing K1, K2, K3, then K19. Are you able to explain the sequence of events that occurred?



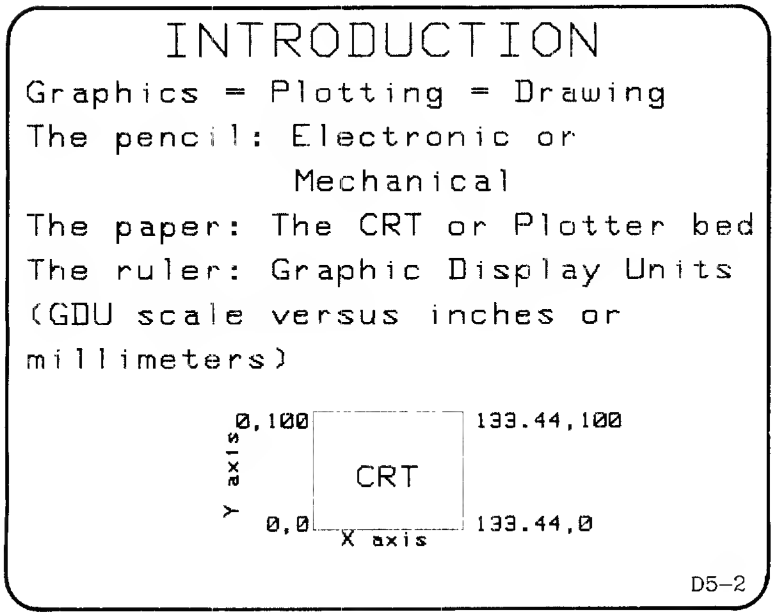
GRAPHICS PROGRAMMING

Objectives:

- Display data graphically.
    Curves, Bars, Pies
- Create and manipulate objects.
    Draw, Move, Rotate

D5-1

NOTES



INTRODUCTION

Graphics = Plotting = Drawing

The pencil: Electronic or
Mechanical

The paper: The CRT or Plotter bed

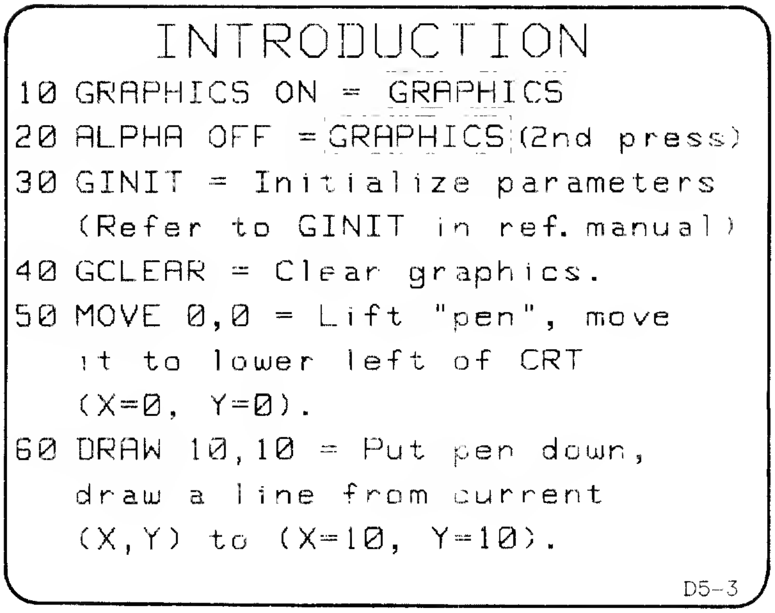
The ruler: Graphic Display Units
(GDU scale versus inches or
millimeters)

0,100
133.44,100
Y axis
CRT
0,0
X axis
133.44,0

D5-2

NOTES

NOTES

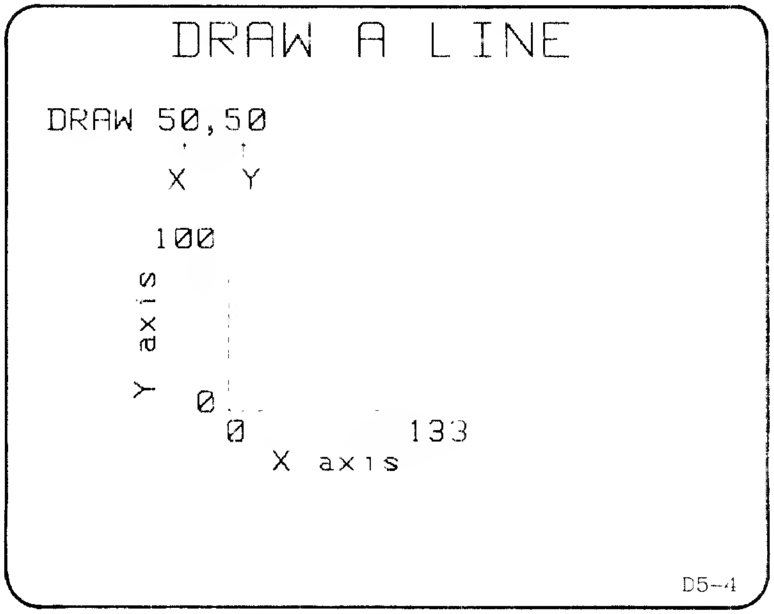


INTRODUCTION

```
10 GRAPHICS ON = GRAPHICS
20 ALPHA OFF = GRAPHICS (2nd press)
30 GINIT = Initialize parameters
   (Refer to GINIT in ref. manual)
40 GCLEAR = Clear graphics.
50 MOVE 0,0 = Lift "pen", move
   it to lower left of CRT
   (X=0, Y=0).
60 DRAW 10,10 = Put pen down,
   draw a line from current
   (X,Y) to (X=10, Y=10).
```

D5-3

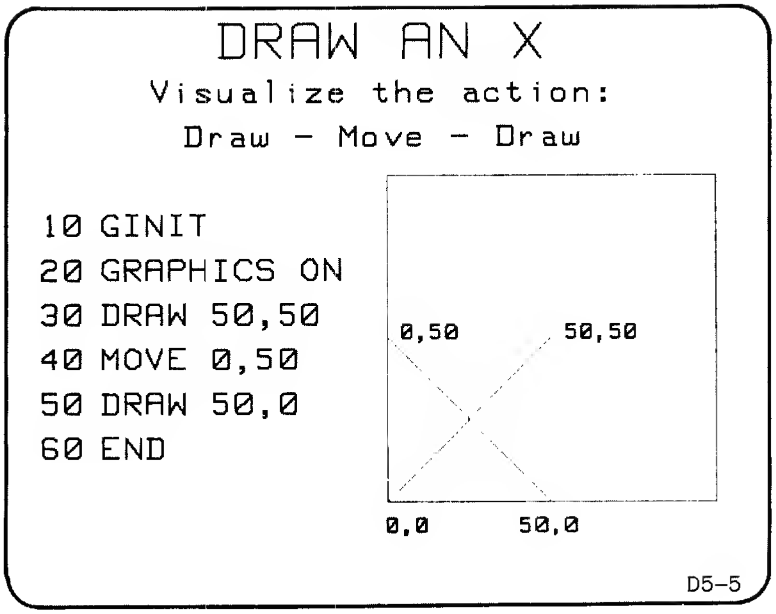
NOTES



DRAW A LINE

```
DRAW 50,50
```

D5-4



DRAW AN X

Visualize the action:

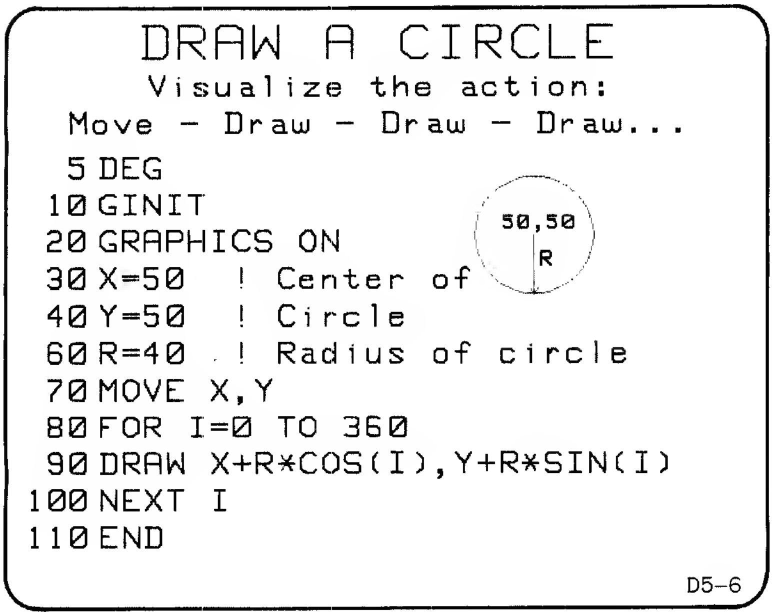
Draw - Move - Draw

```
10 GINIT
20 GRAPHICS ON
30 DRAW 50,50
40 MOVE 0,50
50 DRAW 50,0
60 END
```

0,50
50,50
0,0
50,0

D5-5

NOTES



DRAW A CIRCLE

Visualize the action:

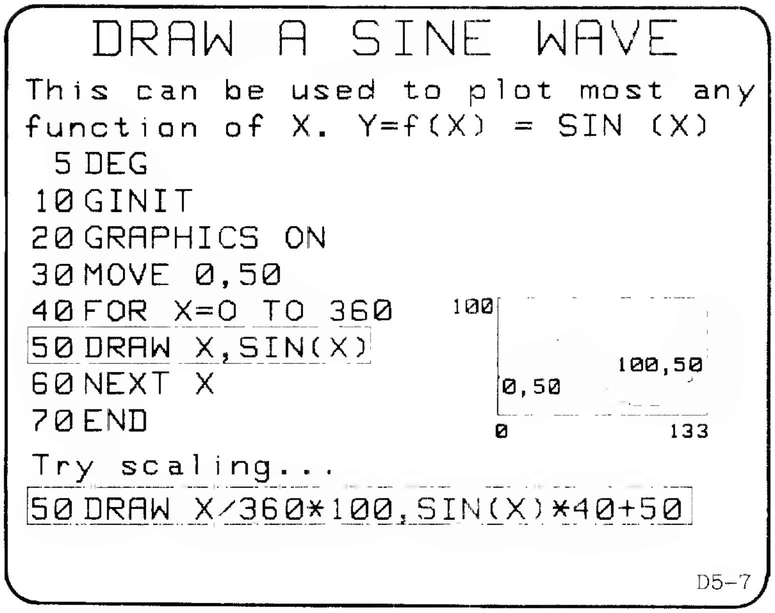
Move - Draw - Draw - Draw...

```
  5 DEG
 10 GINIT
 20 GRAPHICS ON
 30 X=50    ! Center of
 40 Y=50    ! Circle
 60 R=40    ! Radius of circle
 70 MOVE X,Y
 80 FOR I=0 TO 360
 90 DRAW X+R*COS(I),Y+R*SIN(I)
100 NEXT I
110 END
```

D5-6

NOTES

NOTES



DRAW A SINE WAVE

This can be used to plot most any function of X. Y=f(X) = SIN (X)

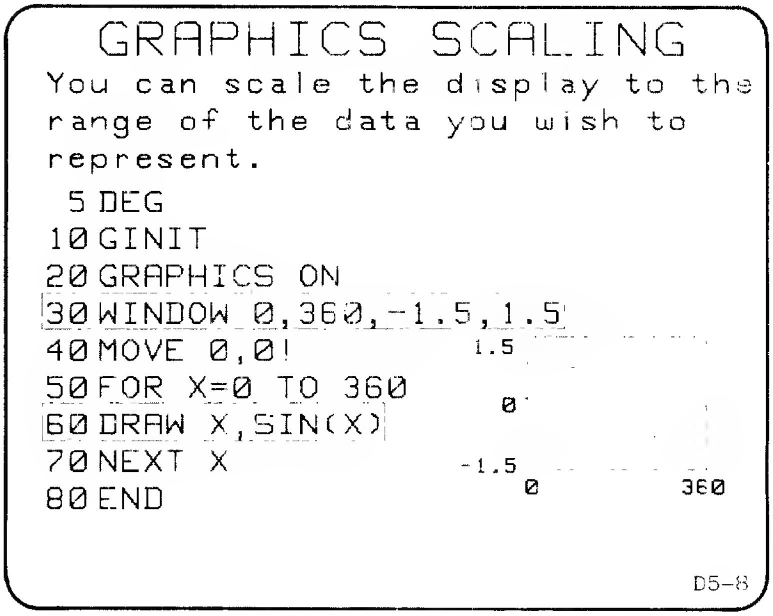
```
 5 DEG
10 GINIT
20 GRAPHICS ON
30 MOVE Ø,5Ø
40 FOR X=O TO 36Ø
50 DRAW X,SIN(X)
60 NEXT X
70 END
```

Try scaling...

```
50 DRAW X/36Ø*1ØØ,SIN(X)*4Ø+5Ø
```

D5-7

NOTES

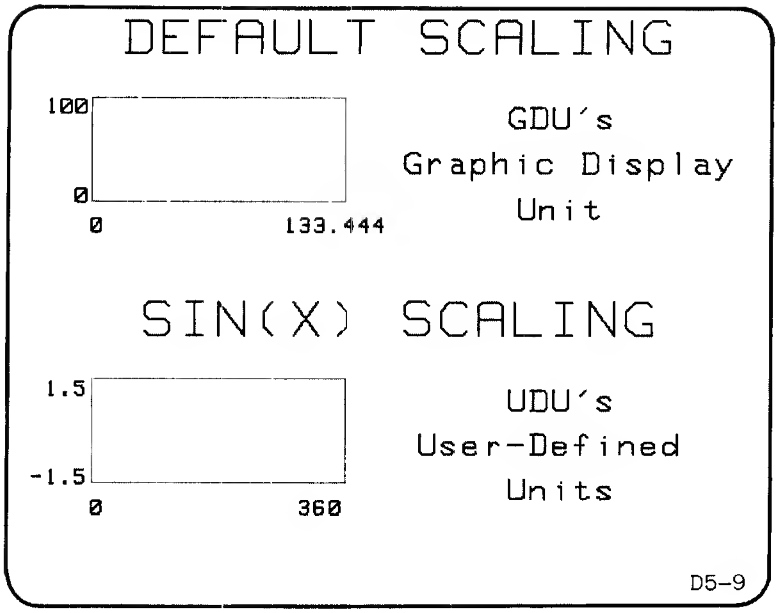


GRAPHICS SCALING

You can scale the display to the range of the data you wish to represent.

```
 5 DEG
10 GINIT
20 GRAPHICS ON
30 WINDOW Ø,36Ø,-1.5,1.5
40 MOVE Ø,Ø!
50 FOR X=Ø TO 36Ø
60 DRAW X,SIN(X)
70 NEXT X
80 END
```

D5-8



DEFAULT SCALING

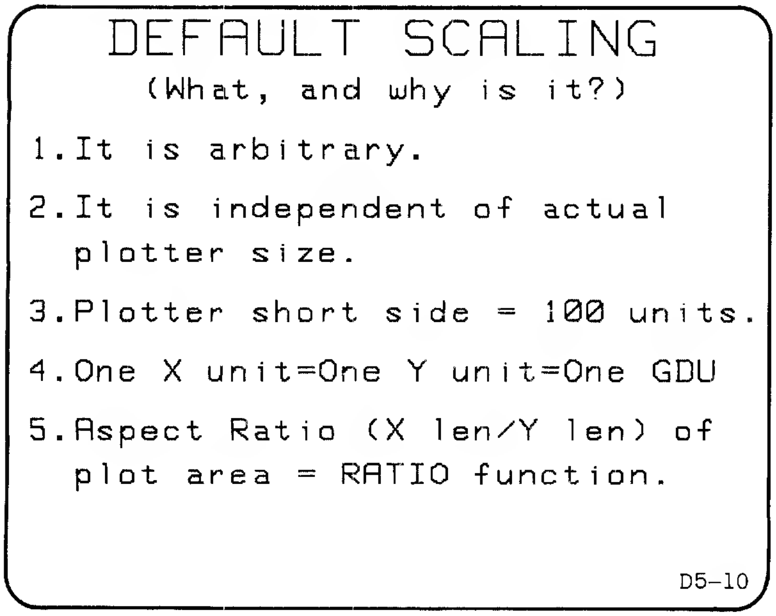
GDU's
Graphic Display
Unit

SIN(X) SCALING

UDU's
User-Defined
Units

D5-9

NOTES



DEFAULT SCALING

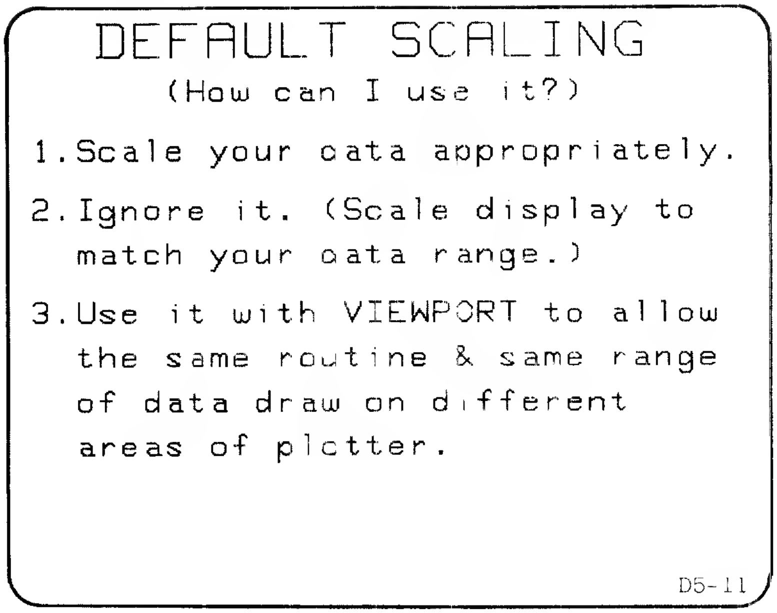
(What, and why is it?)

1. It is arbitrary.
2. It is independent of actual plotter size.
3. Plotter short side = 100 units.
4. One X unit=One Y unit=One GDU
5. Aspect Ratio (X len/Y len) of plot area = RATIO function.

D5-10

NOTES

NOTES



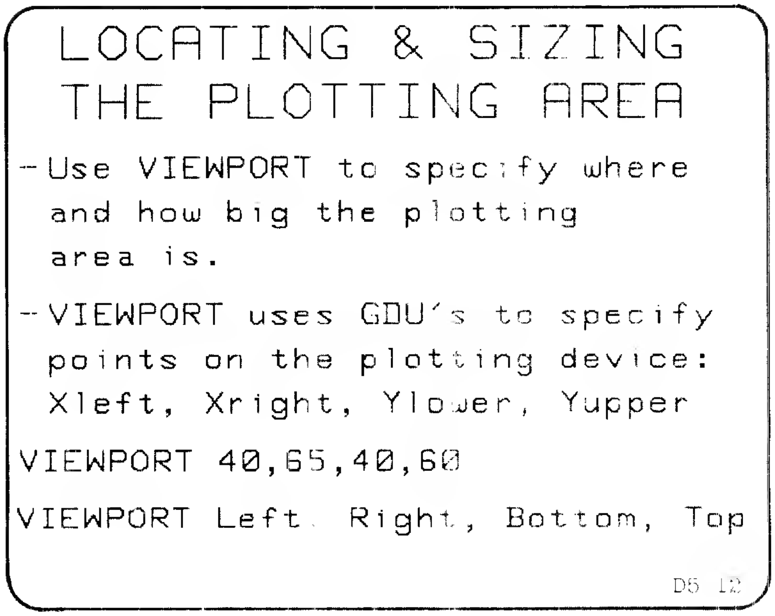
DEFAULT SCALING

(How can I use it?)

1. Scale your oata appropriately.
2. Ignore it. (Scale display to match your oata range.)
3. Use it with VIEWPORT to allow the same routine & same range of data draw on different areas of plctter.

D5-11

NOTES

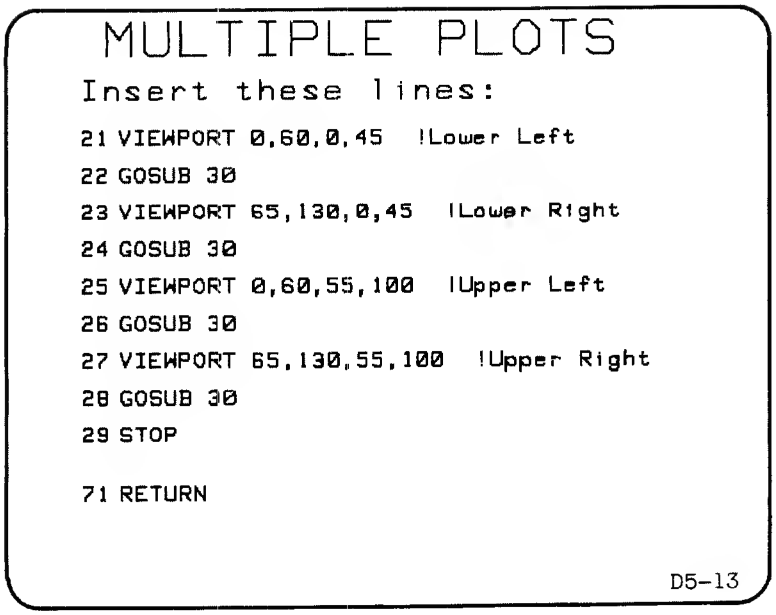


LOCATING & SIZING THE PLOTTING AREA

- Use VIEWPORT to specify where and how big the plotting area is.
- VIEWPORT uses GDU's to specify points on the plotting device: Xleft, Xright, Ylower, Yupper

```
VIEWPORT 40,65,40,60
VIEWPORT Left, Right, Bottom, Top
```

D5-12



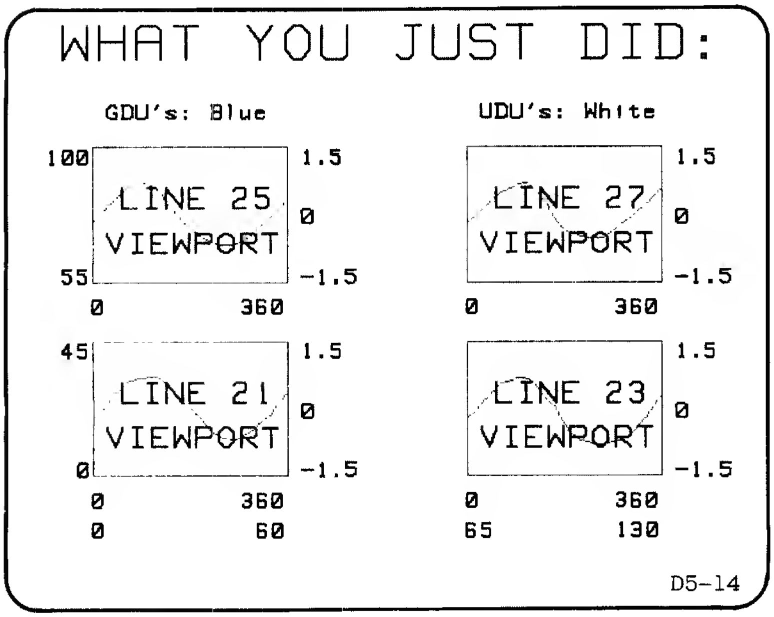
MULTIPLE PLOTS

Insert these lines:

```
21 VIEWPORT 0,60,0,45   !Lower Left
22 GOSUB 30
23 VIEWPORT 65,130,0,45   !Lower Right
24 GOSUB 30
25 VIEWPORT 0,60,55,100   !Upper Left
26 GOSUB 30
27 VIEWPORT 65,130,55,100   !Upper Right
28 GOSUB 30
29 STOP

71 RETURN
```

D5-13

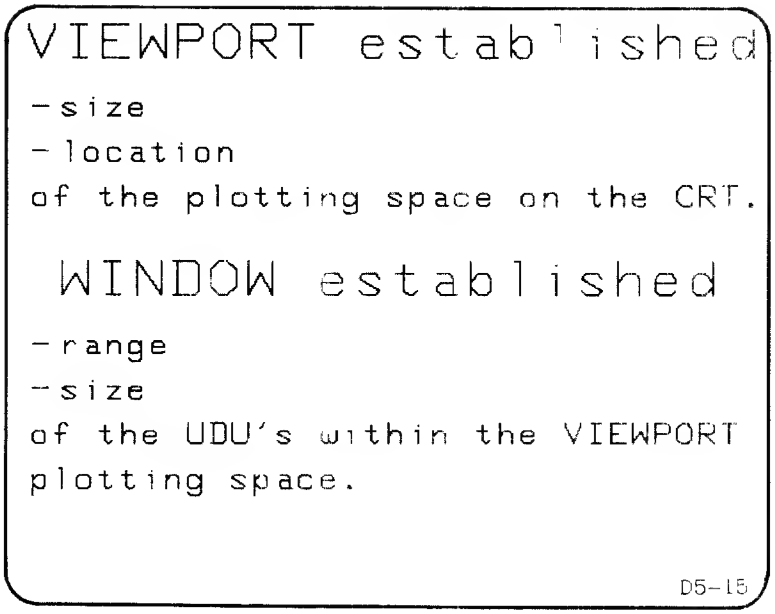
NOTES



WHAT YOU JUST DID:

D5-14

NOTES



VIEWPORT established

- size
- location

of the plotting space on the CRT.

WINDOW established

- range
- size

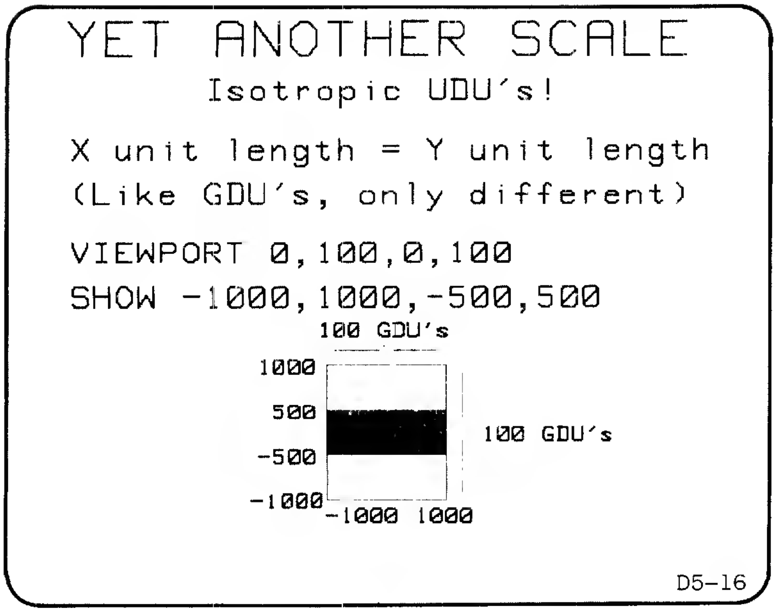
of the UDU's within the VIEWPORT plotting space.

D5-15

EXERCISE 29

Modify the program "CIRCLE" so that the circle is drawn inside a window of 100 X 100.

What happens to the circle? Can you explain why? Be sure you understand what happened before continuing on to the following topics.



YET ANOTHER SCALE

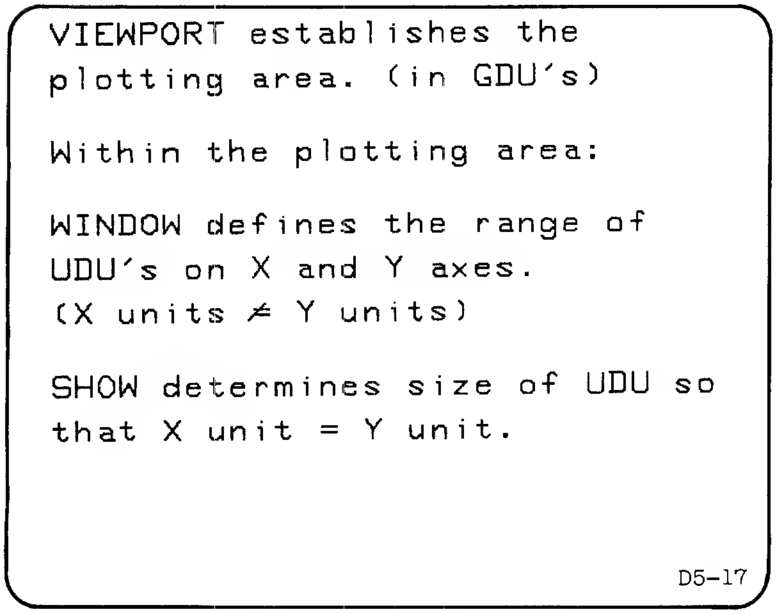
Isotropic UDU's!

X unit length = Y unit length
(Like GDU's, only different)

```
VIEWPORT 0,100,0,100
SHOW -1000,1000,-500,500
```

D5-16

NOTES



VIEWPORT establishes the plotting area. (in GDU's)

Within the plotting area:

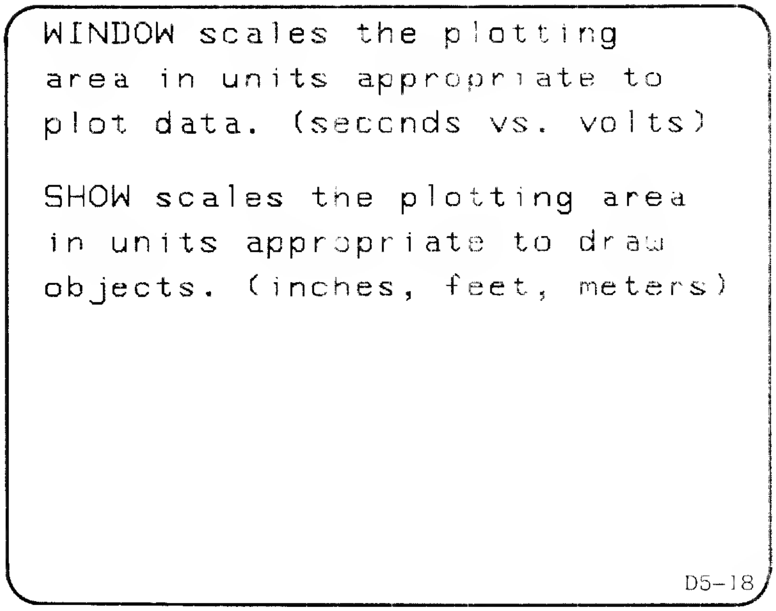
WINDOW defines the range of UDU's on X and Y axes.
(X units ≠ Y units)

SHOW determines size of UDU so that X unit = Y unit.

D5-17

NOTES

NOTES

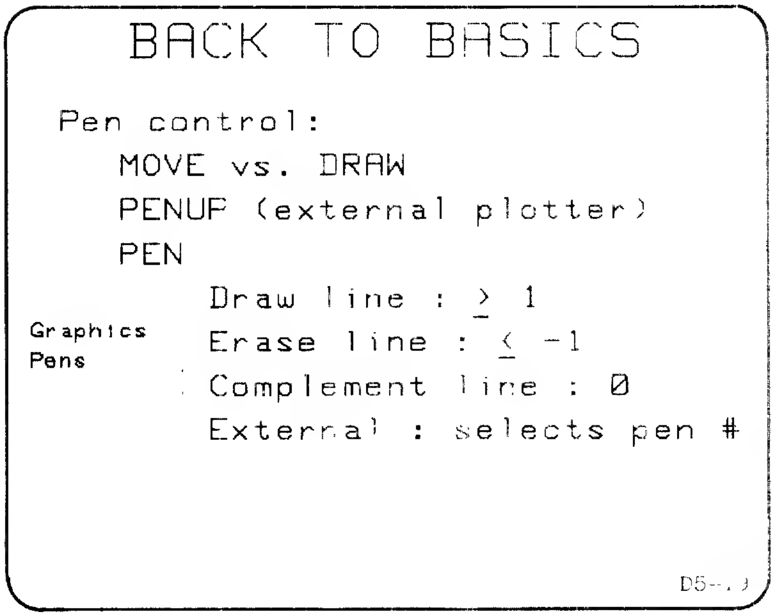


WINDOW scales the plotting area in units appropriate to plot data. (seconds vs. volts)

SHOW scales the plotting area in units appropriate to draw objects. (inches, feet, meters)

D5-18

NOTES



BACK TO BASICS

Pen control:

MOVE vs. DRAW

PENUP (external plotter)

PEN

Graphics Pens

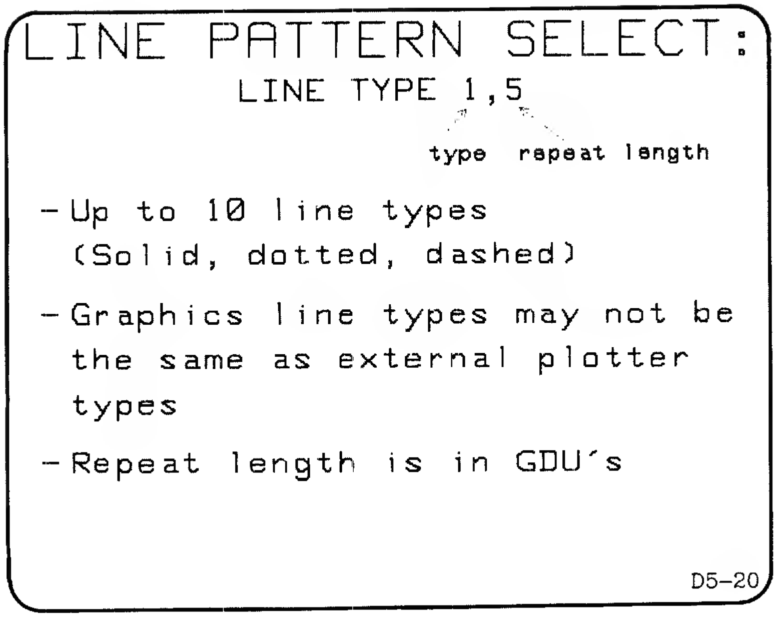
Draw line : ≥ 1

Erase line : ≤ -1

Complement line : 0

External : selects pen #

D5-19



LINE PATTERN SELECT:

LINE TYPE 1,5

type
repeat length

- Up to 10 line types (Solid, dotted, dashed)
- Graphics line types may not be the same as external plotter types
- Repeat length is in GDU´s

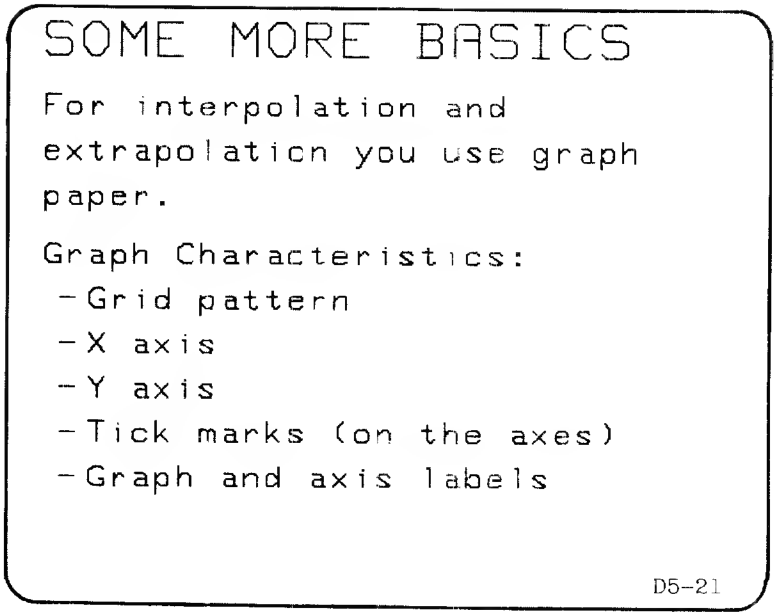
D5-20

EXERCISE 30

Modify the program "FOUR_SIN" so that each curve is drawn with a different line type. Choose line-types appropriate for drawing continuous curves.

Be aware that line type affects the frame drawn around the plotting area (via the FRAME statement). How might the program be modified so that the frame is always drawn with line type 1?

NOTES



SOME MORE BASICS

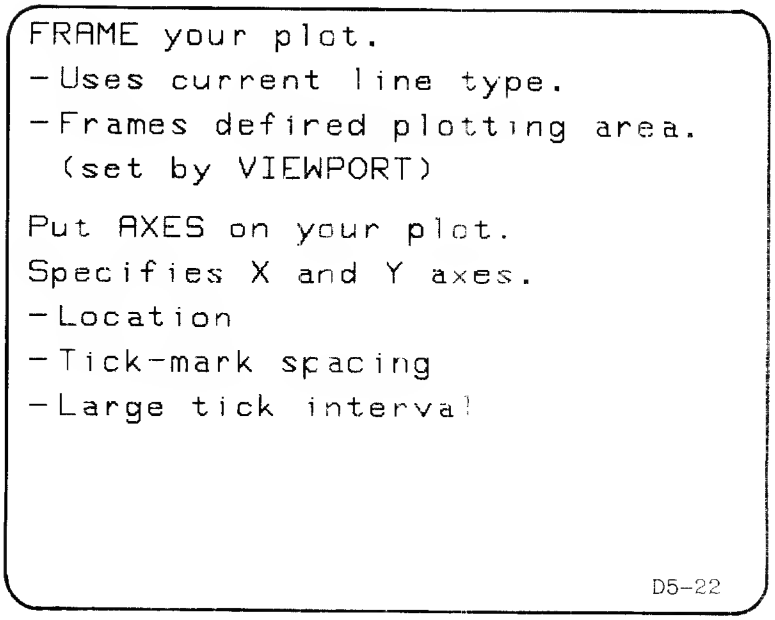
For interpolation and extrapolation you use graph paper.

Graph Characteristics:

- Grid pattern
- X axis
- Y axis
- Tick marks (on the axes)
- Graph and axis labels

D5-21

NOTES



FRAME your plot.

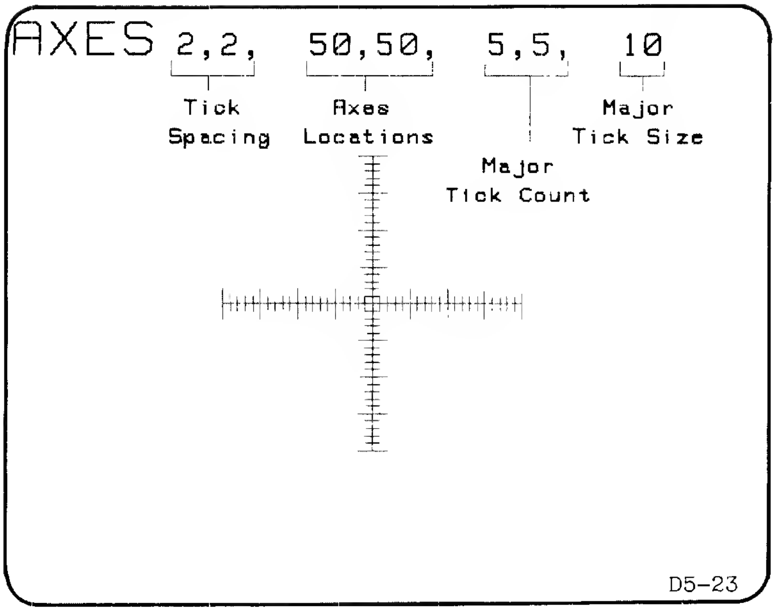
- Uses current line type.
- Frames defined plotting area. (set by VIEWPORT)

Put AXES on your plot.

Specifies X and Y axes.

- Location
- Tick-mark spacing
- Large tick interval

D5-22



AXES 2,2, 50,50, 5,5, 10

Tick Spacing

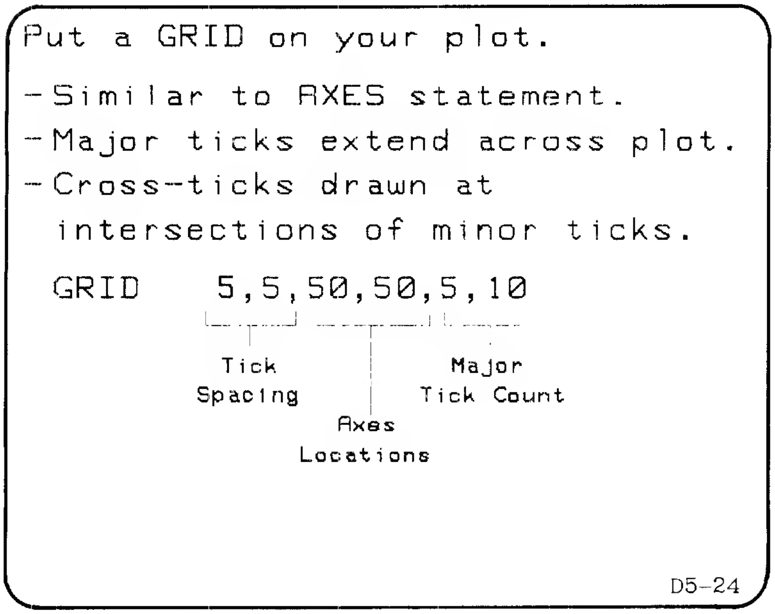
Axes Locations

Major Tick Count

Major Tick Size

D5-23

NOTES



Put a GRID on your plot.

- Similar to AXES statement.
- Major ticks extend across plot.
- Cross-ticks drawn at intersections of minor ticks.

GRID 5,5,50,50,5,10

Tick Spacing

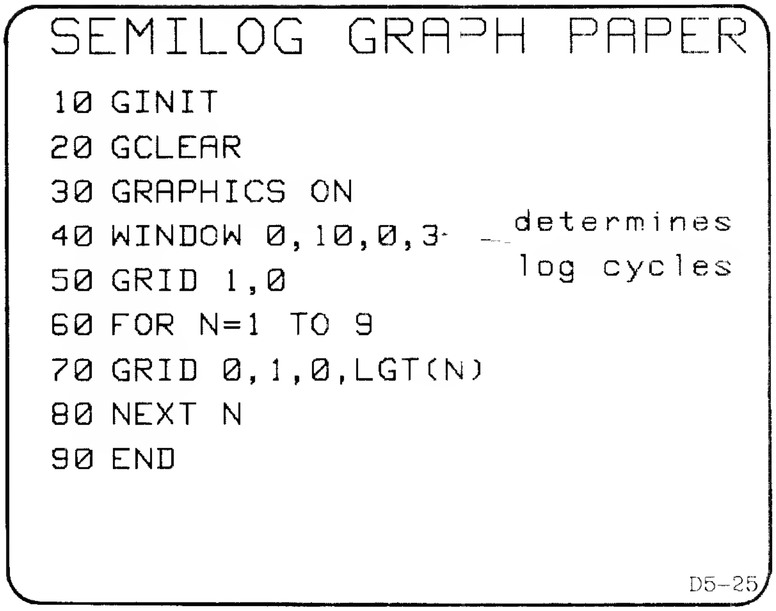
Major Tick Count

Axes Locations

D5-24

NOTES

NOTES



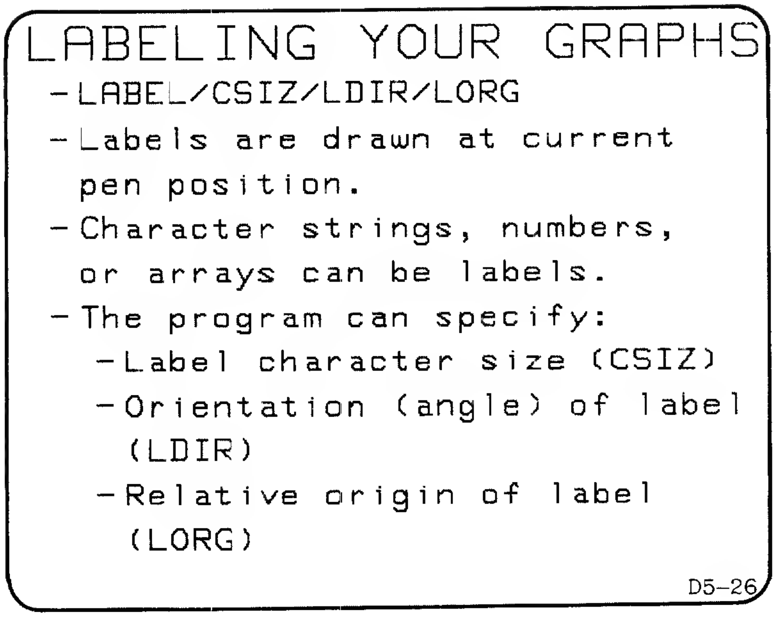
SEMILOG GRAPH PAPER

```
10 GINIT
20 GCLEAR
30 GRAPHICS ON
40 WINDOW 0,10,0,3 — determines
50 GRID 1,0          log cycles
60 FOR N=1 TO 9
70 GRID 0,1,0,LGT(N)
80 NEXT N
90 END
```

D5-25

EXERCISE 31

Modify the semilog grid program to produce a 4 cycle Y axis loglog grid. You could either add another FOR-NEXT loop or modify the WINDOW and GRID statements to draw lines on both the X and Y axes on an LGT basis.

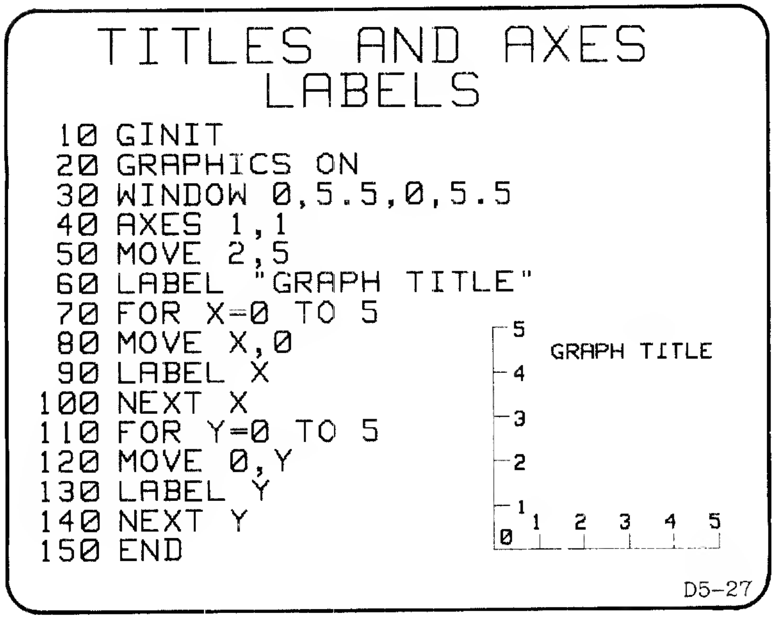


LABELING YOUR GRAPHS

- LABEL/CSIZ/LDIR/LORG
- Labels are drawn at current pen position.
- Character strings, numbers, or arrays can be labels.
- The program can specify:
  - Label character size (CSIZ)
  - Orientation (angle) of label (LDIR)
  - Relative origin of label (LORG)

D5-26

NOTES



TITLES AND AXES LABELS

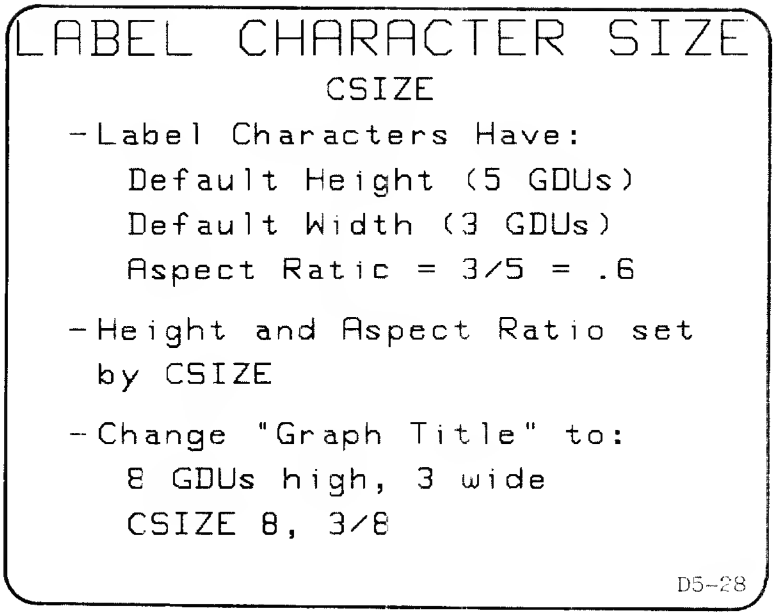
```
 10 GINIT
 20 GRAPHICS ON
 30 WINDOW 0,5.5,0,5.5
 40 AXES 1,1
 50 MOVE 2,5
 60 LABEL "GRAPH TITLE"
 70 FOR X=0 TO 5
 80 MOVE X,0
 90 LABEL X
100 NEXT X
110 FOR Y=0 TO 5
120 MOVE 0,Y
130 LABEL Y
140 NEXT Y
150 END
```

GRAPH TITLE
5
4
3
2
1
0
1
2
3
4
5

D5-27

NOTES

NOTES



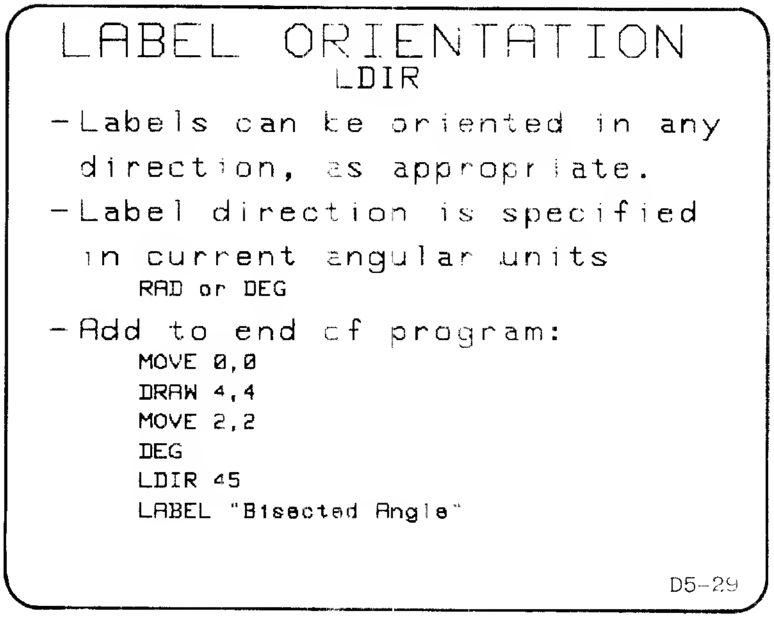
LABEL CHARACTER SIZE

CSIZE

- Label Characters Have:
  Default Height (5 GDUs)
  Default Width (3 GDUs)
  Aspect Ratic = 3/5 = .6
- Height and Aspect Ratio set by CSIZE
- Change "Graph Title" to:
  8 GDUs high, 3 wide
  CSIZE 8, 3/8

D5-28

NOTES



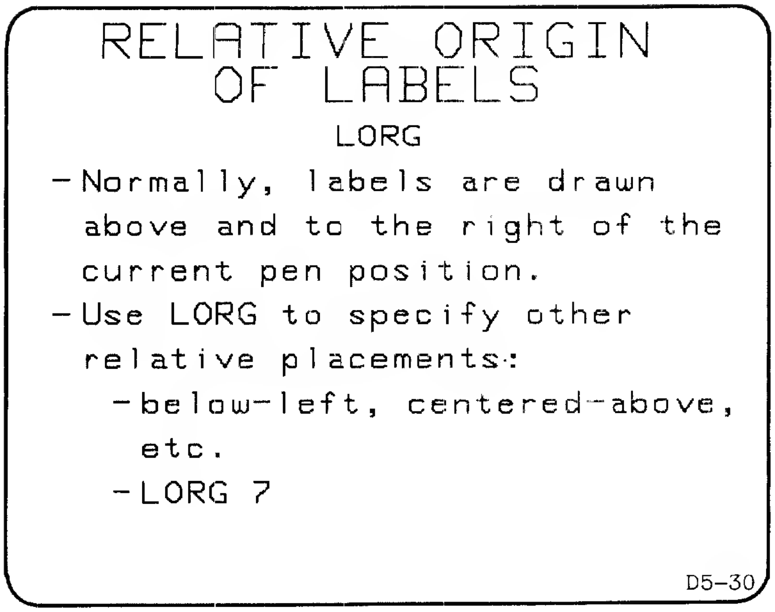
LABEL ORIENTATION

LDIR

- Labels can be oriented in any direction, as appropriate.
- Label direction is specified in current angular units
  RAD or DEG
- Add to end of program:

```
MOVE 0,0
DRAW 4,4
MOVE 2,2
DEG
LDIR 45
LABEL "Bisected Angle"
```

D5-29



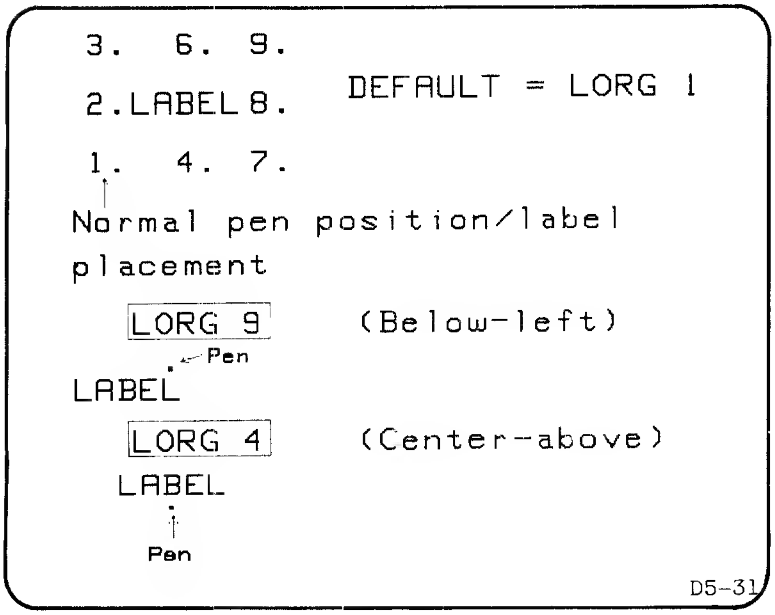
RELATIVE ORIGIN OF LABELS

LORG

- Normally, labels are drawn above and to the right of the current pen position.
- Use LORG to specify other relative placements:
  - below-left, centered-above, etc.
  - LORG 7

D5-30

NOTES



```
3.   6.  9.
                DEFAULT = LORG 1
2.LABEL 8.

1.   4.  7.
```

LORG 9 (Below-left)

LORG 4 (Center-above)

D5-31

NOTES

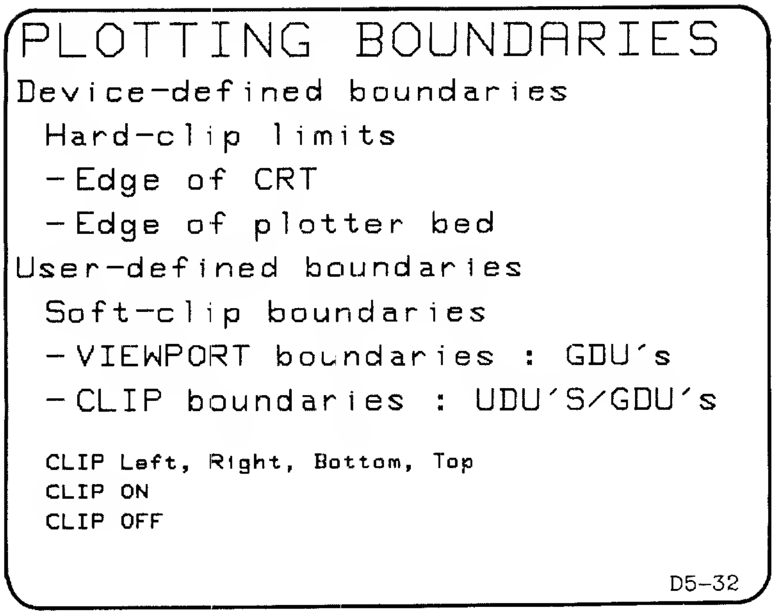
EXERCISE 32

Modify the program "LABELS" so that the X axis labels are below the axis and the Y axis labels are to the left of the axis.

EXERCISE 33

Modify the program "READ_SIN" to plot the data after it is read off the file "SINDAT". Your plot routine should be written as a subprogram, with the number of data elements and the data array passed as formal parameters.

The plot should be framed, with labels and axes as appropriate. Contrast these graphic results with the printout of the data you performed previously.



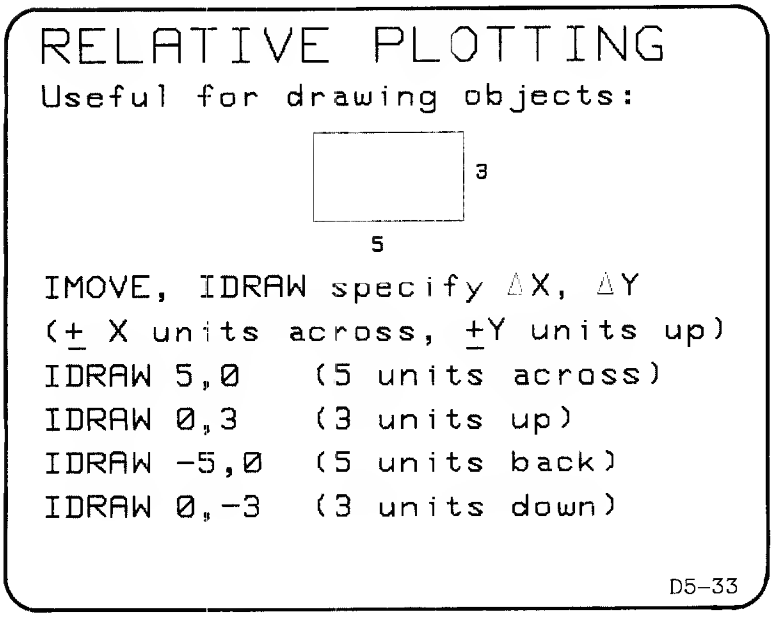
PLOTTING BOUNDARIES

Device-defined boundaries
  Hard-clip limits
  -Edge of CRT
  -Edge of plotter bed
User-defined boundaries
  Soft-clip boundaries
  -VIEWPORT boundaries : GDU's
  -CLIP boundaries : UDU'S/GDU's

```
CLIP Left, Right, Bottom, Top
CLIP ON
CLIP OFF
```

D5-32

NOTES



RELATIVE PLOTTING

Useful for drawing objects:

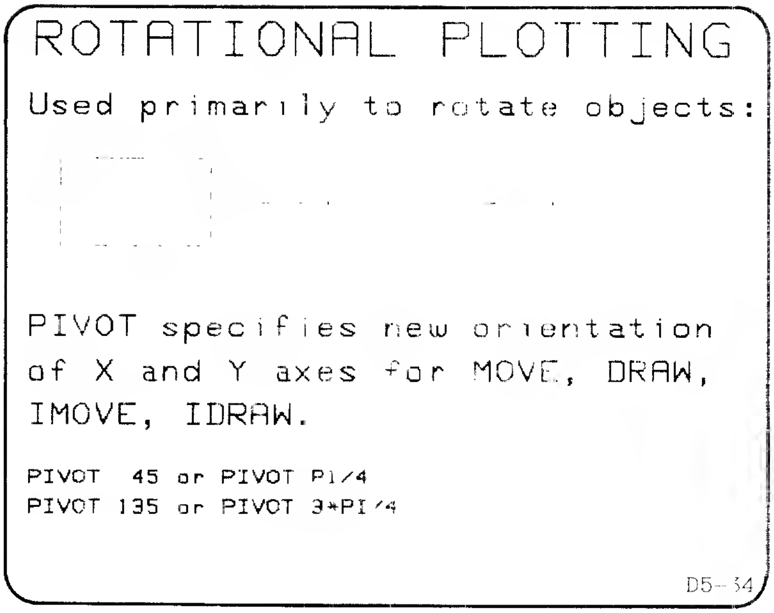
IMOVE, IDRAW specify ΔX, ΔY
(± X units across, ±Y units up)

```
IDRAW 5,0    (5 units across)
IDRAW 0,3    (3 units up)
IDRAW -5,0   (5 units back)
IDRAW 0,-3   (3 units down)
```

D5-33

NOTES

NOTES



ROTATIONAL PLOTTING

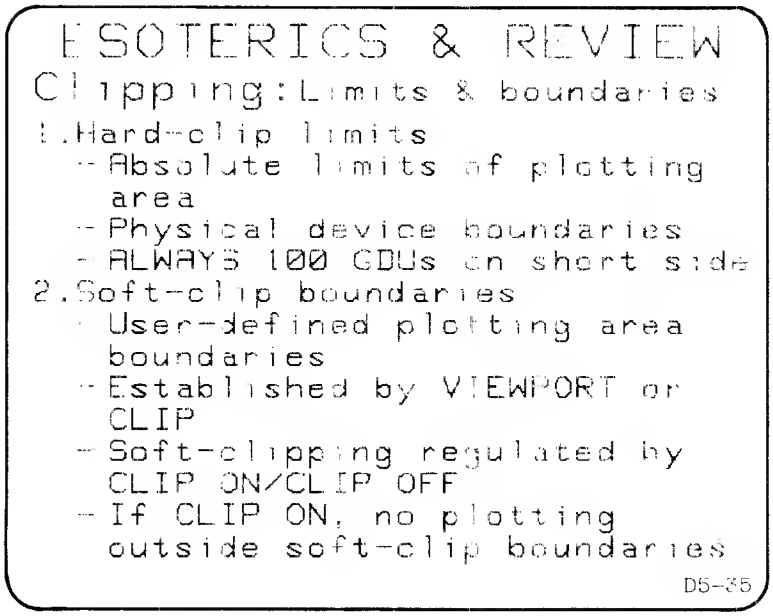
Used primarily to rotate objects:

PIVOT specifies new orientation of X and Y axes for MOVE, DRAW, IMOVE, IDRAW.

```
PIVOT  45 or PIVOT PI/4
PIVOT 135 or PIVOT 3*PI/4
```

D5-34

NOTES

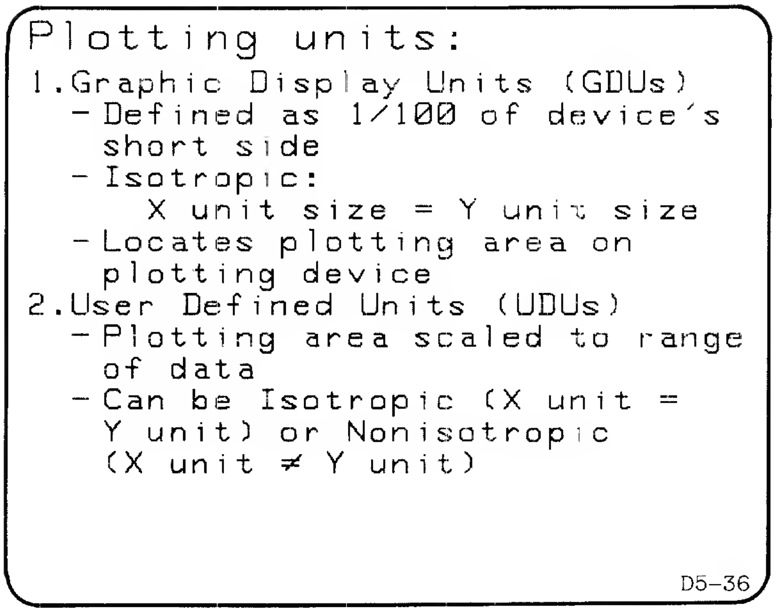


ESOTERICS & REVIEW

Clipping: Limits & boundaries

1. Hard-clip limits
   - Absolute limits of plotting area
   - Physical device boundaries
   - ALWAYS 100 GDUs on short side
2. Soft-clip boundaries
   - User-defined plotting area boundaries
   - Established by VIEWPORT or CLIP
   - Soft-clipping regulated by CLIP ON/CLIP OFF
   - If CLIP ON, no plotting outside soft-clip boundaries

D5-35

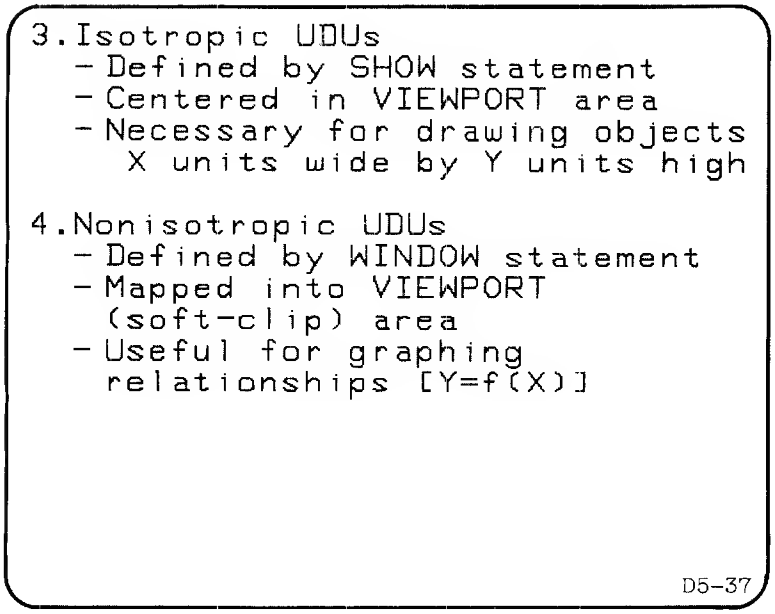


Plotting units:

1. Graphic Display Units (GDUs)
   - Defined as 1/100 of device's short side
   - Isotropic:
     X unit size = Y unit size
   - Locates plotting area on plotting device
2. User Defined Units (UDUs)
   - Plotting area scaled to range of data
   - Can be Isotropic (X unit = Y unit) or Nonisotropic (X unit ≠ Y unit)

D5-36

NOTES



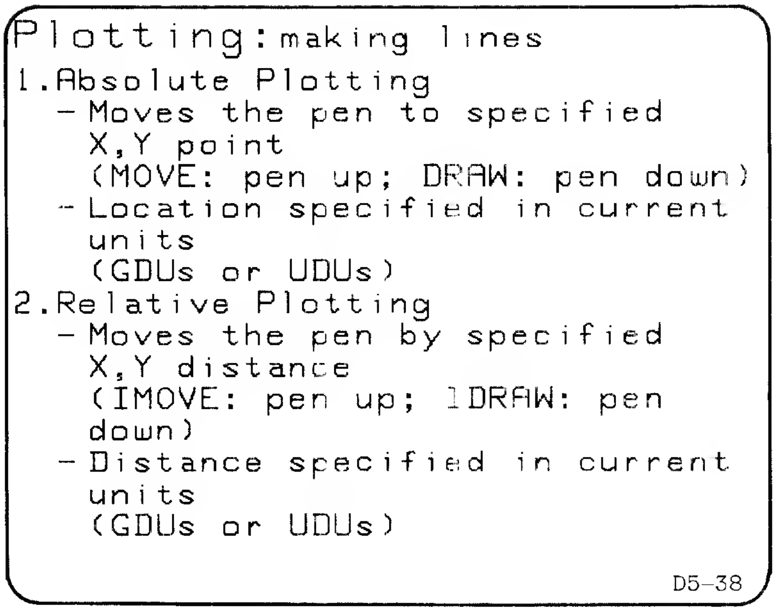
3. Isotropic UDUs
   - Defined by SHOW statement
   - Centered in VIEWPORT area
   - Necessary for drawing objects X units wide by Y units high

4. Nonisotropic UDUs
   - Defined by WINDOW statement
   - Mapped into VIEWPORT (soft-clip) area
   - Useful for graphing relationships [Y=f(X)]

D5-37

NOTES

NOTES

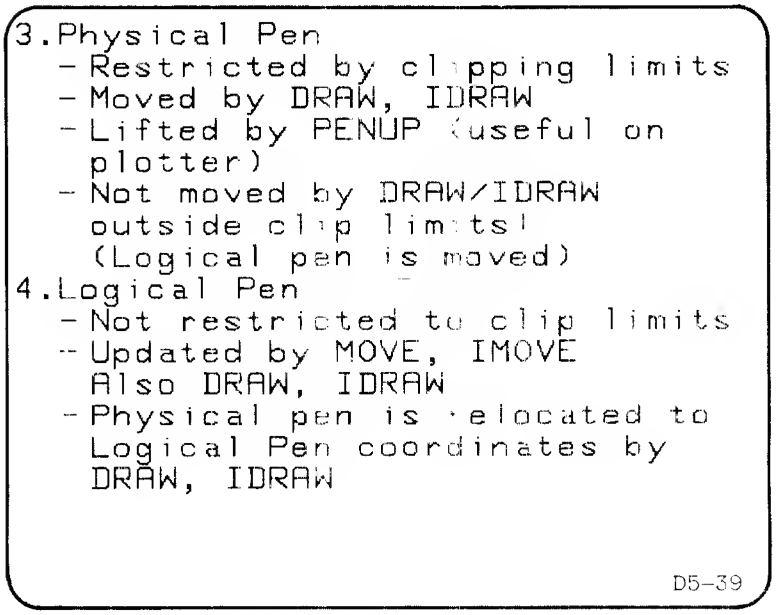


Plotting: making lines

1. Absolute Plotting
   - Moves the pen to specified X,Y point (MOVE: pen up; DRAW: pen down)
   - Location specified in current units (GDUs or UDUs)
2. Relative Plotting
   - Moves the pen by specified X,Y distance (IMOVE: pen up; IDRAW: pen down)
   - Distance specified in current units (GDUs or UDUs)

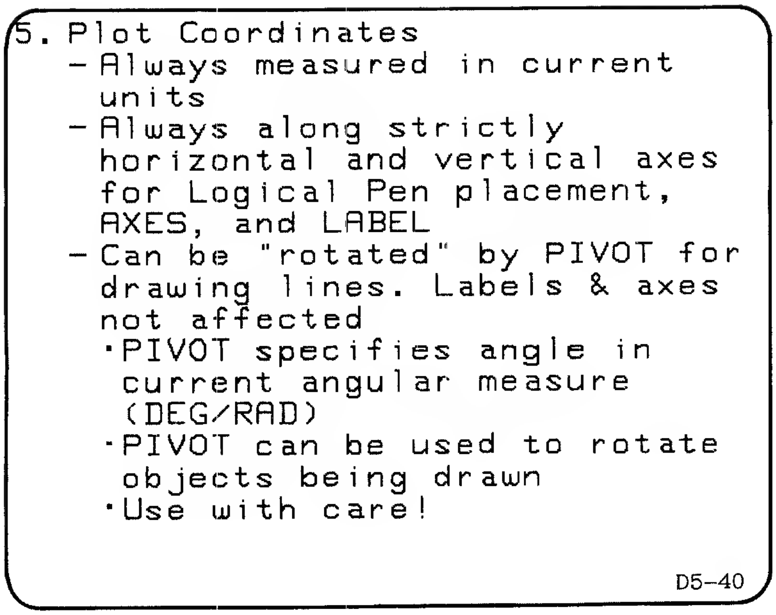
D5-38

NOTES



3. Physical Pen
   - Restricted by clipping limits
   - Moved by DRAW, IDRAW
   - Lifted by PENUP (useful on plotter)
   - Not moved by DRAW/IDRAW outside clip limits! (Logical pen is moved)
4. Logical Pen
   - Not restricted to clip limits
   - Updated by MOVE, IMOVE Also DRAW, IDRAW
   - Physical pen is relocated to Logical Pen coordinates by DRAW, IDRAW

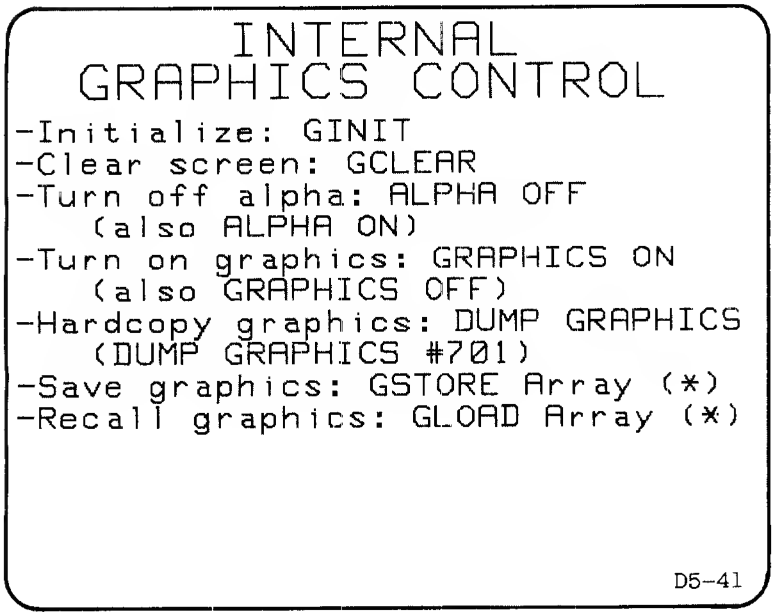
D5-39



5. Plot Coordinates
   - Always measured in current units
   - Always along strictly horizontal and vertical axes for Logical Pen placement, AXES, and LABEL
   - Can be "rotated" by PIVOT for drawing lines. Labels & axes not affected
     - ·PIVOT specifies angle in current angular measure (DEG/RAD)
     - ·PIVOT can be used to rotate objects being drawn
     - ·Use with care!

D5-40

NOTES



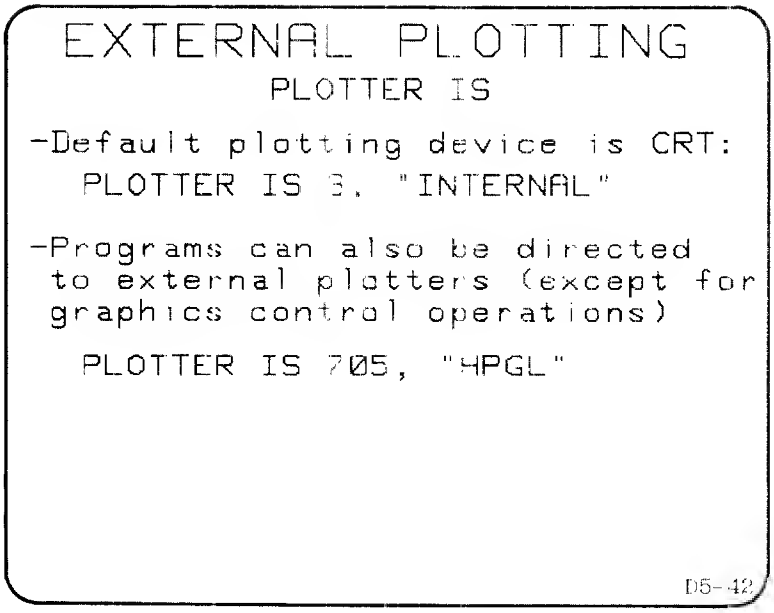
INTERNAL GRAPHICS CONTROL

-Initialize: GINIT
-Clear screen: GCLEAR
-Turn off alpha: ALPHA OFF
   (also ALPHA ON)
-Turn on graphics: GRAPHICS ON
   (also GRAPHICS OFF)
-Hardcopy graphics: DUMP GRAPHICS
   (DUMP GRAPHICS #701)
-Save graphics: GSTORE Array (*)
-Recall graphics: GLOAD Array (*)

D5-41

NOTES

NOTES



EXTERNAL PLOTTING

PLOTTER IS

-Default plotting device is CRT:

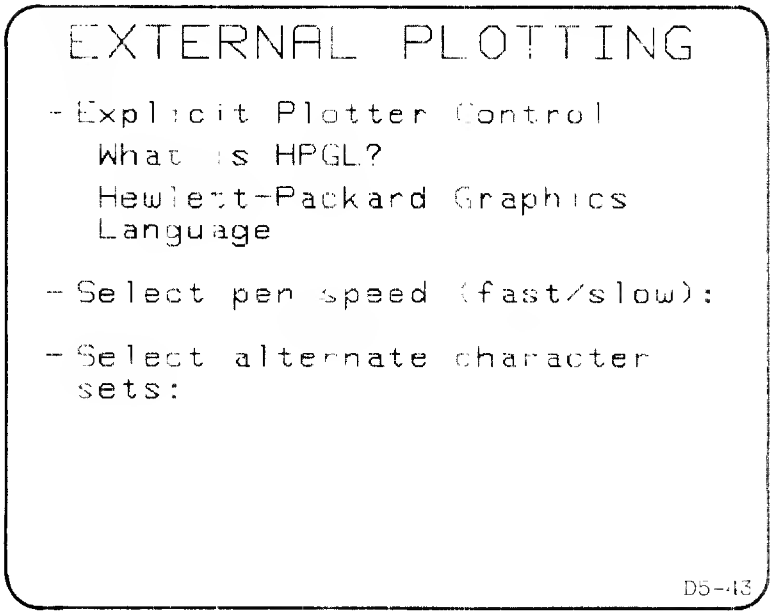
```
PLOTTER IS 3, "INTERNAL"
```

-Programs can also be directed to external plotters (except for graphics control operations)

```
PLOTTER IS 7Ø5, "HPGL"
```

D5-42

NOTES



EXTERNAL PLOTTING

- Explicit Plotter Control
  What is HPGL?
  Hewlett-Packard Graphics Language
- Select pen speed (fast/slow):
- Select alternate character sets:

D5-43

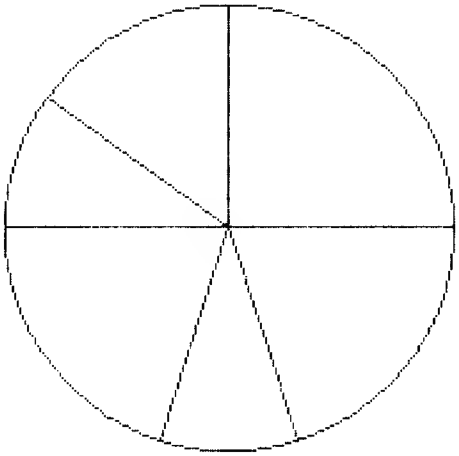
EXERCISE 34

Write a program that plots percentage data as a pie-chart graph.

There are a number of ways to attack the problem, but one way is to read the next percent and call a circle-drawing subprogram that draws the given percent of a circle.

Example data :   25, 15, 10, 20, 10, 20,

Resulting Pie Chart :



Write a program that implements a bar-meter type readout of a changing signal.

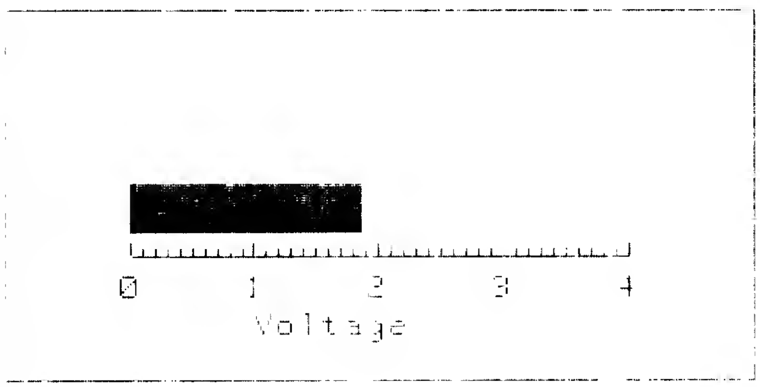
Incoming signal values should be serviced by an interrupt service routine - in this case, a knob-service routine.

While in the routine, update the bar-meter by drawing to the right or erasing to the left, depending on the new signal value (greater to or less than the old signal value).

(Although this program uses the knob as its signal source, that source could easily be data from an HP-IB instrument.)

Your main program here should consist only of set-up and an endless loop. In a more complex application the main program could be executing various other tasks, since updating the display is the responsibility of the service routine.

Example readout :



D1-24

```
10     !  "EDIT1"
20     !  The following lines (100,110,120) are for
30     !  editing.
40     !  The exclamation marks are equivalent to
50     !  the standard BASIC REM(ARK) statement.
60     !
70     !  Remove the exclamation mark, correct the
80     !  line, then press ENTER to store it.
90     !
100!  PRENT "This keyword is misspelled."
110!  PRINT "Your NAME here.
120!  PRINT  Your ADDRESS here"
130 !
140 !
150 GOTO 190 ! This is an illegal GOTO at RUN time
160 !
170 !
180  END
190  PRINT   ! This line must be deleted.
200  GOTO 180! So must this one.
```

D1-31

```
10 ! SAVE "REVIEW"
20 REM  Program to compute Mean, Variance, and
30 REM  Standard Deviation
40 !
50 !
60 REM  Initialization section
70   OPTION BASE 1
80   DIM X(10)
90   DATA 20,45,13,64,85,97,59,34,72,6
100  FOR I=1 TO 10
110     READ X(I)
120  NEXT I
130  Sum=0
140  Sumofsquares=0
150  Numofitems=10
160  !
170  !
180  REM  Compute sum and sum of squares
190  FOR I=1 TO Numofitems
200     Sum=Sum+X(I)
210     Sumofsquares=Sumofsquares+X(I)*X(I)
220  NEXT I
230  !
240  !
250  Mean=Sum/Numofitems
260  Variance=(Sumofsquares-Sum*Sum/Numofitems)/(Numofitems-1)
270  Std_dev=SQR(Variance)
280  GOSUB 320
290  STOP
300  !
310  !
320  PRINT "Index ";TAB(11);"Data"
330  FOR I=1 TO Numofitems
340     PRINT TAB(2);I;TAB(11);X(I)
350  NEXT I
360  !
370  PRINT
380  PRINT "Mean= ";DROUND(Mean,5)
390  PRINT "Variance= ";DROUND(Variance,5)
400  PRINT "Standard Deviation= ";DROUND(Std_dev,5)
410  RETURN
420  END
```

```
10 ! SAVE "LOOPTIME"
20 ! This program can be used to measure the execution time of BASIC program sta
tements.
30 ! To use it, replace line 130  with the program line to be timed.
40     INTEGER One,Two,Three    ! Some integer vars
50     REAL Four,Five,Six       ! Some real vars
60     SET TIME 0
70 ! Measure FOR-NEXT loop time.
80        FOR I=1 TO 10000
90        NEXT I
100    Time1=TIMEDATE
110! Now try different statements in line 130.
120       FOR I=1 TO 10000
130       ! ****** Test statement goes here. ******
140       NEXT I
150    Time2=TIMEDATE
160! The difference between the two times, divided by 10000 is the statement tim
e.
170    Statement_time=(Time2-Time1) MOD 86400/10000
180    PRINT "Execution time is",Statement_time*1000;" milliseconds."
190    END
```

Solution 1

```
10! SAVE "MONTH_DAY"
20!        This program takes an input of the form        mm/dd/yy and produces a
n output of the form
30!     Month Day, Year
40!
50     OPTION BASE 1          ! Lower bound=1
60     DIM Month$(12)[10]
70     Month$(1)="JANUARY"   ! Initialize names
80     Month$(2)="FEBRUARY"  ! of months.
90     Month$(3)="MARCH"
100    Month$(4)="APRIL"
110    Month$(5)="MAY"
120    Month$(6)="JUNE"
130    Month$(7)="JULY"
140    Month$(8)="AUGUST"
150    Month$(9)="SEPTEMBER"
160    Month$(10)="OCTOBER"
170    Month$(11)="NOVEMBER"
180    Month$(12)="DECEMBER"
190!
200    INPUT "Enter mm/dd/yy",String$
210!
220!     Now find the number of the month.
230    Answer$=Month$(VAL(String$))
240!
250!     Set a pointer past the first "/".
260    Temp=POS(String$,"/")+1
270!
280!     Start building the output as Month & day.
290    Answer$=Answer$&" "&String$[Temp;POS(String$[Temp],"/")-1]
300    Answer$=Answer$&","
310!
320!     Now set a pointer past the second "/".
330    Temp=Temp+POS(String$[Temp],"/")
340!
350!     Add the year information as "19yy".
360    Answer$=Answer$&"19"&String$[Temp;2]
370    PRINT Answer$
380    END
```

Solution 2

```
10 ! SAVE "SCH_RPL"
20    DIM Search_in$(150)[100]
30    !  The next line defines the name of the                    ASCII file to be sear
ched.
40    Program$="CIRCLE"
50    !  Read in the ASCII file until end-of-file
60    ASSIGN @Pipe TO Program$
70    ON END @Pipe GOSUB Done
80    I=0
90    REPEAT
100      I=I+1
110      ENTER @Pipe;Search_in$(I)
120   UNTIL Eof
130   Num_elem=I
140 GOSUB Search_replace
150   INPUT "Shall I print the entire array?",S$
160     IF POS(S$,"y") OR POS(S$,"Y") THEN
170        FOR I=1 TO Num_elem
180        PRINT Search_in$(I)
190        NEXT I
200     ELSE
210     END IF
220   STOP
230 Done:    ASSIGN @Pipe TO *    ! Stop reading
240          Eof=1
250          RETURN
260 !*********************************************
270 ! Append your subroutine starting here.
280 ! GET "TEMP"
```

```
10! SAVE "SCHRPL_SUB"
20 Search_replace: ! One possible solution.
30       INPUT "Enter the search string",A$
40       INPUT "Enter the replace string",B$
50     FOR I=1 TO Num_elem
60       X=POS(Search_in$(I),A$)
70       IF X THEN
80          PRINT "The line was:"
90          PRINT Search_in$(I)
100         Search_in$(I)=Search_in$(I)[1,X-1]&B$&Search_in$(I)[X+LEN(A$)]
110         PRINT "The line now is:"
120         PRINT Search_in$(I)
130         PRINT
140         WAIT .3
150      ELSE
160      END IF
170    NEXT I
180      PRINT
190      PRINT
200 RETURN
210    END
```

```
10 ! SAVE "IFTHENELSE"
20    INPUT "Please enter some number",Number
30   FOR Count=15 TO 0 STEP -1
40   !
50    IF BIT(Number,Count) THEN
60        PRINT "1";
70    ELSE
80        PRINT "0";
90    END IF
100  !
110  NEXT Count
120   PRINT
130   GOTO 20
140   END
```

Solution 3

```
10! SAVE "SELECTCASE"
20  INPUT "Enter a number",Number
30  FOR Count=15 TO 0 STEP -1
40       SELECT BIT(Number,Count)
50          CASE 0
60          PRINT "0";
70          CASE 1
80          PRINT "1";
90       END SELECT
100 NEXT Count
110 END
```

Solution 4a

```
10 ! SAVE "UPPERCASE"
20    INPUT "ENTER A STRING",A$
30    !
40    !  Look at one character at a time
50  FOR I=1 TO LEN(A$)
60    SELECT A$[I,I]
70    !
80    !  If the character is in the range:
90    CASE "a" TO "z"
100   !  then subtract 32 from it´s ASCII value
110    A$[I,I]=CHR$(NUM(A$[I,I])-32)
120   END SELECT
130 NEXT I
140   PRINT A$
150   END
```

Solution 4b

```
10 ! SAVE "UPC_LWC"
20     !  Function$ determines whether this program              does uppercase or low
ercase.
30     Function$="LWC"    ! Either UPC or LWC
40     !
50     DIM A$[80]
60     INPUT "ENTER A STRING",A$
70     !
80     !  Look at one character at a time
90  FOR I=1 TO LEN(A$)
100    SELECT A$[I,I]
110     !
120    CASE "a" TO "z"
130     !  If the character is in range and the                   function is UPC,
140     !  then subtract 32 from it's ASCII value
150       IF Function$="UPC" THEN
160          A$[I,I]=CHR$(NUM(A$[I,I])-32)
170       ELSE
180       END IF
190     CASE "A" TO "Z"
200     !  Now try to see if function is LWC:
210       IF Function$="LWC" THEN
220          A$[I,I]=CHR$(NUM(A$[I,I])+32)
230       ELSE
240       END IF
250    END SELECT
260 NEXT I
270    PRINT A$
280    END
```

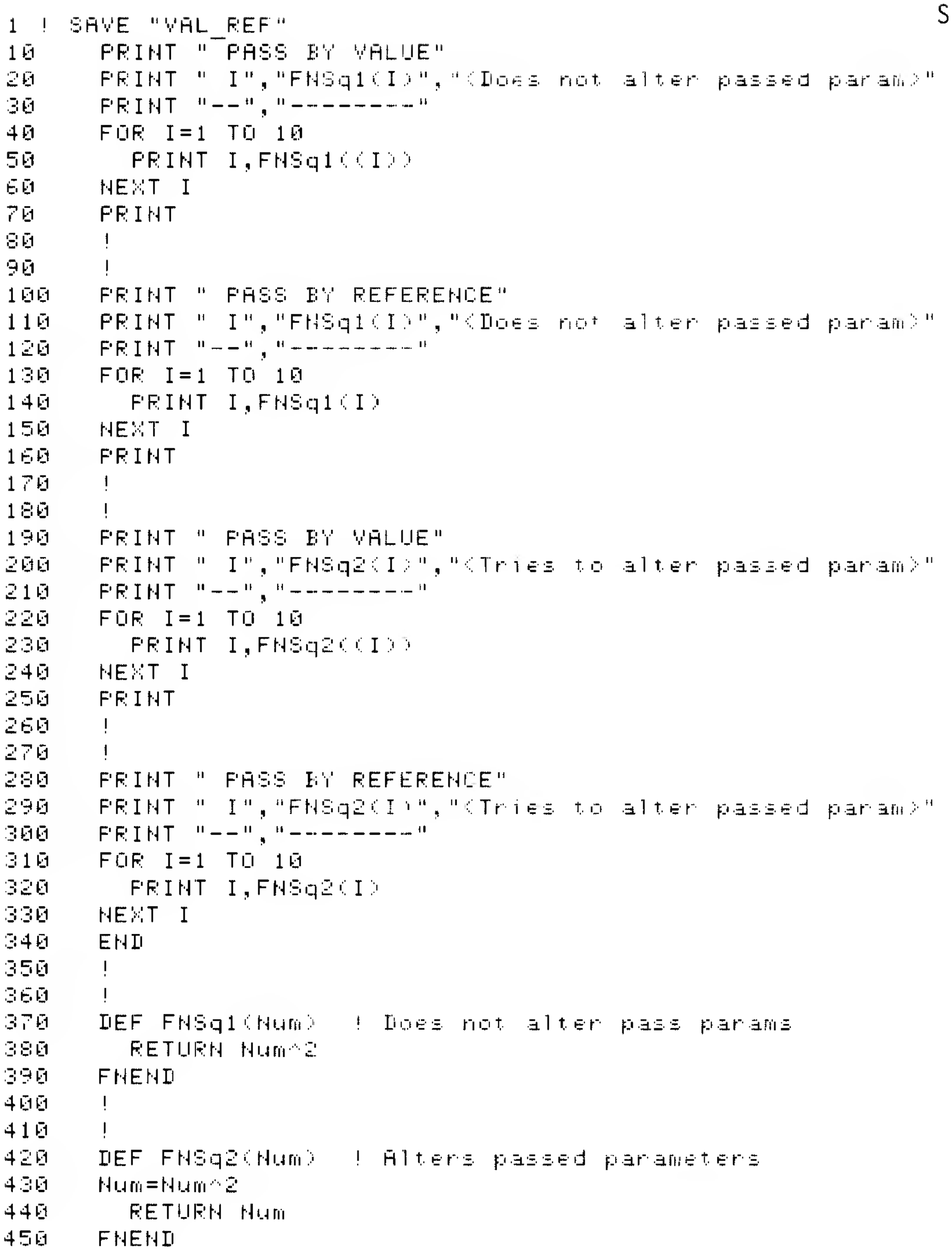
Solution 5

```
10! SAVE "REPEAT"
20  INPUT "NUMBER?",Number
30  Count=15
40  REPEAT
50    IF BIT(Number,Count) THEN
60       PRINT "1";
70    ELSE
80       PRINT "0";
90    END IF
100   Count=Count-1
110   UNTIL Count<0
120 PRINT
130   END
```

Solution 6

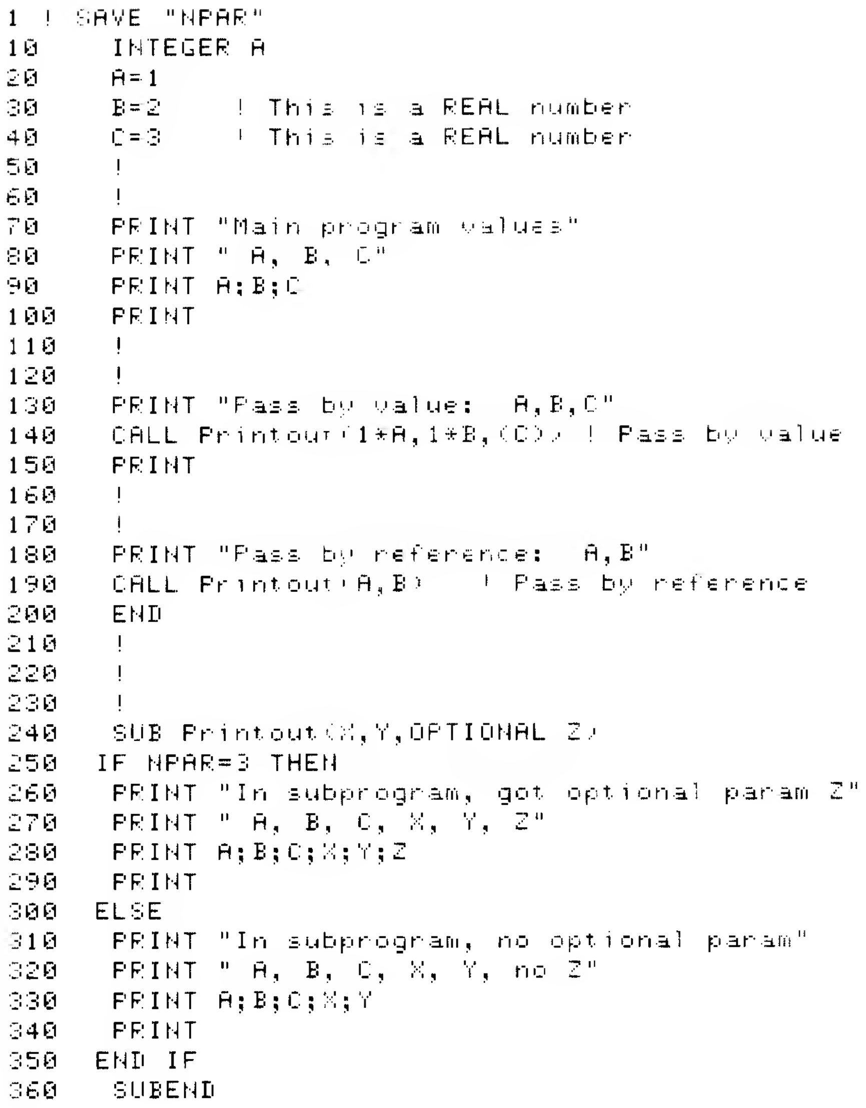
```
10! SAVE "WHILE"
20  INPUT "NUMBER?",Number
30  Count=15
40    WHILE Count>=0
50      IF BIT(Number,Count) THEN
60         PRINT "1";
70      ELSE
80         PRINT "0";
90      END IF
100   Count=Count-1
110   END WHILE
120  PRINT
130  END
```

Solution 7



```
1 ! SAVE "VAL_REF"
10    PRINT " PASS BY VALUE"
20    PRINT " I","FNSq1(I)","<Does not alter passed param>"
30    PRINT "--","--------"
40    FOR I=1 TO 10
50      PRINT I,FNSq1((I))
60    NEXT I
70    PRINT
80    !
90    !
100   PRINT " PASS BY REFERENCE"
110   PRINT " I","FNSq1(I)","<Does not alter passed param>"
120   PRINT "--","--------"
130   FOR I=1 TO 10
140     PRINT I,FNSq1(I)
150   NEXT I
160   PRINT
170   !
180   !
190   PRINT " PASS BY VALUE"
200   PRINT " I","FNSq2(I)","<Tries to alter passed param>"
210   PRINT "--","--------"
220   FOR I=1 TO 10
230     PRINT I,FNSq2((I))
240   NEXT I
250   PRINT
260   !
270   !
280   PRINT " PASS BY REFERENCE"
290   PRINT " I","FNSq2(I)","<Tries to alter passed param>"
300   PRINT "--","--------"
310   FOR I=1 TO 10
320     PRINT I,FNSq2(I)
330   NEXT I
340   END
350   !
360   !
370   DEF FNSq1(Num)   ! Does not alter pass params
380     RETURN Num^2
390   FNEND
400   !
410   !
420   DEF FNSq2(Num)   ! Alters passed parameters
430   Num=Num^2
440     RETURN Num
450   FNEND
```

Solution 8

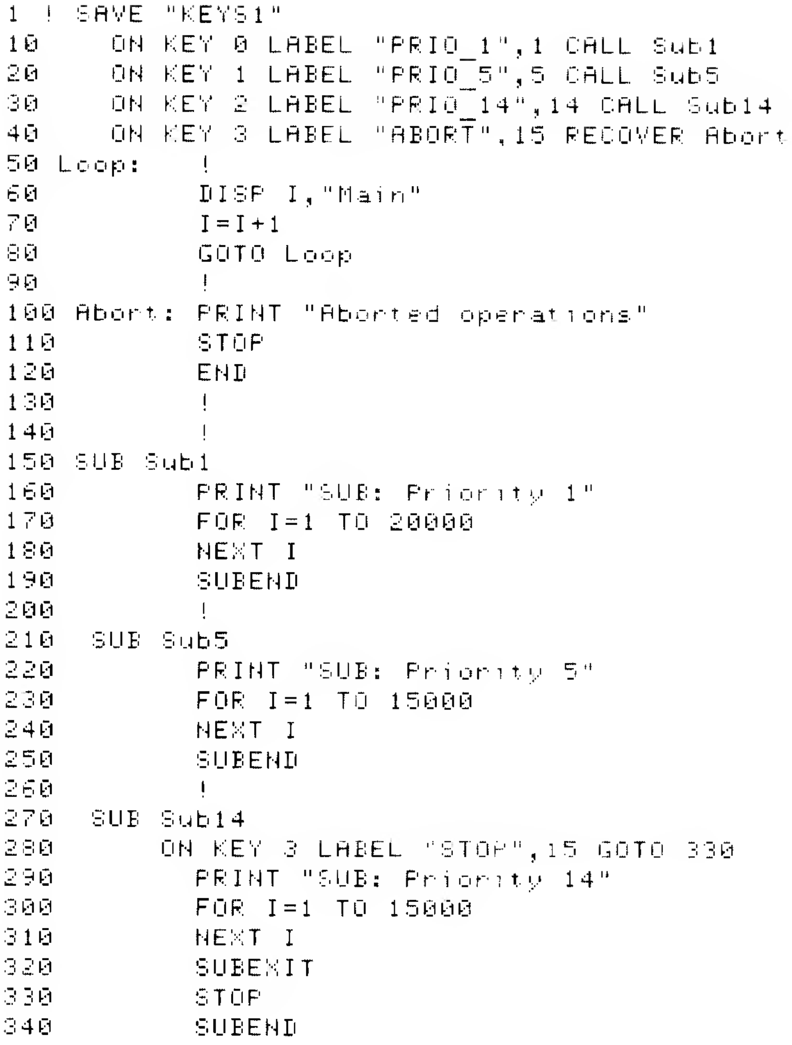


```
1 ! SAVE "NPAR"
10    INTEGER A
20    A=1
30    B=2     ! This is a REAL number
40    C=3     ! This is a REAL number
50    !
60    !
70    PRINT "Main program values"
80    PRINT " A, B, C"
90    PRINT A;B;C
100   PRINT
110   !
120   !
130   PRINT "Pass by value:  A,B,C"
140   CALL Printout(1*A,1*B,(C))  ! Pass by value
150   PRINT
160   !
170   !
180   PRINT "Pass by reference:  A,B"
190   CALL Printout(A,B)    ! Pass by reference
200   END
210   !
220   !
230   !
240   SUB Printout(X,Y,OPTIONAL Z)
250  IF NPAR=3 THEN
260   PRINT "In subprogram, got optional param Z"
270   PRINT " A, B, C, X, Y, Z"
280   PRINT A;B;C;X;Y;Z
290   PRINT
300  ELSE
310   PRINT "In subprogram, no optional param"
320   PRINT " A, B, C, X, Y, no Z"
330   PRINT A;B;C;X;Y
340   PRINT
350  END IF
360   SUBEND
```

Solution 9

```
1 ! SAVE "LABEL_COM"
10     A=1
20     B=2
30     C=3
40     COM A,B,C
50     PRINT "Values in Main before call"
60     PRINT " A, B, C, L, M, N"
70     PRINT A;B;C;L;M;N
80     !
90     !
100    CALL Printout1
110    PRINT "Values in Main after call"
120    PRINT " A, B, C, L, M, N"
130    PRINT A;B;C;L;M;N
140    !
150    CALL Printout2
160    END
170    !
180    !
190    !
200    SUB Printout1
210    COM A,B,C
220    COM /Crypto/ L,M,N
230    A=4
240    B=5
250    C=6
260    L=7
270    M=8
280    N=9
290    PRINT
300    PRINT "First Sub COM  values "
310    PRINT " A, B, C, L, M, N"
320    PRINT A;B;C;L;M;N
330    PRINT
340    SUBEND
350    !
360    SUB Printout2
370    COM /Crypto/ L,M,N
380    PRINT
390    PRINT "Second Sub COM  values "
400    PRINT " A, B, C, L, M, N"
410    PRINT A;B;C;L;M;N
420    PRINT
430    SUBEND
```

Solution 10



```
1 ! SAVE "KEYS1"
10     ON KEY 0 LABEL "PRIO_1",1 CALL Sub1
20     ON KEY 1 LABEL "PRIO_5",5 CALL Sub5
30     ON KEY 2 LABEL "PRIO_14",14 CALL Sub14
40     ON KEY 3 LABEL "ABORT",15 RECOVER Abort
50 Loop:     !
60           DISP I,"Main"
70           I=I+1
80           GOTO Loop
90           !
100 Abort: PRINT "Aborted operations"
110          STOP
120          END
130          !
140          !
150 SUB Sub1
160          PRINT "SUB: Priority 1"
170          FOR I=1 TO 20000
180          NEXT I
190          SUBEND
200          !
210  SUB Sub5
220          PRINT "SUB: Priority 5"
230          FOR I=1 TO 15000
240          NEXT I
250          SUBEND
260          !
270  SUB Sub14
280       ON KEY 3 LABEL "STOP",15 GOTO 330
290          PRINT "SUB: Priority 14"
300          FOR I=1 TO 15000
310          NEXT I
320          SUBEXIT
330          STOP
340          SUBEND
```

Solution 11

```
1 ! SAVE "PRIORITIES"
10    ON KEY 0 LABEL "CALL P5",5 CALL Pri5
20    ON KEY 2 LABEL "CALL P10",10 CALL Pri10
30    ON KEY 4 LABEL "CALL P14",14 CALL Pri14
40    ON KEY 5 LABEL "GSUB P15",15 GOSUB Pri15
50    C=C+1
60    DISP " IN MAIN, COUNTER =";C
70    WAIT .1
80    GOTO 50
90 Pri15:    !
100           FOR X=1 TO 20
110           DISP "IN SUBROUTINE, PRIORITY 15";X
120           WAIT .1
130           NEXT X
140 RETURN
150    END
160    !
170    !
180    !
190 SUB Pri5
200       FOR X=1 TO 20
210           DISP "IN Subprogram, PRIORITY 5:";X
220       WAIT .15
230       NEXT X
240 SUBEND
250 !
260 SUB Pri10
270     ON KEY 4 LABEL "*********",1 CALL Pri14
280       FOR X=1 TO 20
290       DISP "            In Subprogram,PRIORITY 10:";X
300       WAIT .15
310       NEXT X
320 SUBEND
330 !
340 SUB Pri14
350 !   Note that almost any priority here can-               cels the key service.
360     ON KEY 0 LABEL "*********",1 CALL Pri5
370     ON KEY 2 LABEL "*********",1 CALL Pri10
380       FOR X=1 TO 20
390       DISP "                          In subprogram, PRIORITY 14:";X
400       WAIT .15
410       NEXT X
420 SUBEND
```

Solution 12

```
1 ! SAVE "BEEP"
10    ON KNOB .5 GOSUB Beeper
20    DISP "Main: ";X
30    X=X+1
40    GOTO 20
41    !
50 Beeper:    !
60            Y=ABS(KNOBX)
61            DISP "Service: ";Y
70            BEEP Y*10,.2
71            WAIT .2
80            RETURN
90    END
```

```
1 ! SAVE "MAIN"
2     LOADSUB ALL FROM "KEYSUBS"
10    ON KEY 0 LABEL "CALL P5",5 CALL Pri5
20    ON KEY 2 LABEL "CALL P10",10 CALL Pri10
30    ON KEY 4 LABEL "CALL P14",14 CALL Pri14
40    ON KEY 5 LABEL "GSUB P15",15 GOSUB Pri15
50    C=C+1
60    DISP " IN MAIN, COUNTER =";C
70    WAIT .1
80    GOTO 50
90 Pri15:    !
100           FOR X=1 TO 20
110           DISP "IN SUBROUTINE, PRIORITY 15";X
120           WAIT .1
130           NEXT X
140 RETURN
150   END
```

```
10 ! STORE "KEYSUBS"
190 SUB Pri5
200      FOR X=1 TO 20
210          DISP "IN Subprogram, PRIORITY 5:";X
220      WAIT .15
230      NEXT X
240 SUBEND
250 !
260 SUB Pri10
270    ON KEY 4 LABEL "********",1 CALL Pri14
280      FOR X=1 TO 20
290      DISP "           In Subprogram,PRIORITY 10:";X
300      WAIT .15
310      NEXT X
320 SUBEND
330 !
340 SUB Pri14
350 !   Note that almost any priority here can-           cel: the key service.
360    ON KEY 0 LABEL "********",1 CALL Pri5
370    ON KEY 2 LABEL "********",1 CALL Pri10
380      FOR X=1 TO 20
390      DISP "                        In subprogram, PRIORITY 14:";X
400      WAIT .15
410      NEXT X
420 SUBEND
```

Solution 15

```
1 ! SAVE "GETLOADSUB"
10     ! Put some variables in common so they                don't get clobbered by
 GET
20     !
30     COM /A/ One,Two
40     COM Three,Four
50     !
60     ! Next assign some values to six variables             (some not in COM)
70     !
80     DATA 1,2,3,4,5,6
90     READ One,Two,Three,Four,Five,Six
100    !
110    !
120    PRINT "Before CALL",One;Two;Three;Four;Five;Six
130    CALL Sub_first
140    !
150    !
160    PRINT "After CALL  ",One;Two;Three;Four;Five;Six
170    !
180    !
190    DELSUB Sub_first
200    PRINT "After DELETE",One;Two;Three;Four;Five;Six
210    !
220    !
230    LOADSUB ALL FROM "SUB"
240    CALL Sub_load
250    PRINT "After LOADSUB",One;Two;Three;Four;Five;Six
260    !
270    !
280    ! Now GET a sub at End and execute next line
290    GET "GETSUB",End,Next_line
300 Next_line:  ! This line is executed next.
310    CALL Sub_get
320    PRINT "After GET   ",One;Two;Three;Four;Five;Six
330    END
340    !
350    !
360 End:  SUB Sub_first
370         PRINT "IN SUB Sub_first"
380         SUBEND
```

```
10 ! RE-SAVE "GETSUB"
20 End:  SUB Sub_get
30     PRINT "In SUB Sub_get"
40     SUBEND
```

```
10 ! RE-STORE "SUB"
20 End:SUB Sub_load
30     PRINT "In SUB Sub_load"
40     SUBEND
```

```
1 ! SAVE "ASCII_WRT"
2 ! Writes to "TEST" and reads back in.
3 ! This version is more enhanced than the one
4 ! on the slides...more room.
5 !
6 !
10      CREATE ASCII "TEST",10
11     !
12     !
20      ASSIGN @Name TO "TEST"
30      OUTPUT @Name;"ED","SUE"
40      OUTPUT @Name;"ALVIN"
41     !
50      ASSIGN @Name TO "TEST"
60      ENTER @Name;A$,B$,C$
70      PRINT A$,B$,C$
80      END
```

Solution 16

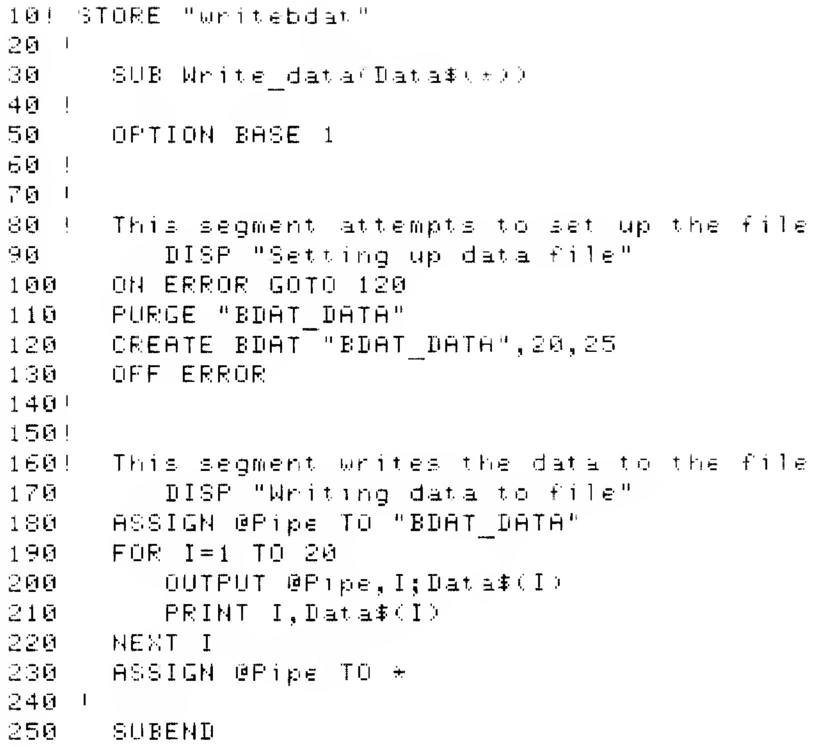
```
1 ! SAVE "UPDATE"
10     ! This program updates the file "OLD_DATA"
20     DIM A$[20]
30     ! Create the destination file
40     CREATE ASCII "NEW_DATA",10
50     !
60     !
70     ASSIGN @Old TO "OLD_DATA"
80     ASSIGN @New TO "NEW_DATA"
90     !
100    FOR I=1 TO 20
110    ENTER @Old;A$    ! Read the data item
120      SELECT A$
130        CASE "MISISSIPPI"   ! Check for update
140          A$="MISSISSIPPI"
150          PRINT A$;TAB(20);I
160        CASE "NABRASKA"     ! Check for update
170          A$="NEBRASKA"
180          PRINT A$;TAB(20);I
190        CASE ELSE
200      END SELECT
210    !
220    OUTPUT @New;A$    ! Write the updated data
230    NEXT I
240    !
250    !
260    ASSIGN @Pipe TO *
270    ASSIGN @New TO *
280   END
```

Solution 17

```
10! SAVE "WRITE_SIN"
20     DEG    ! Set degrees mode
30     ON ERROR GOTO 50   ! In case file exists...
40     CREATE BDAT "SINDAT",1,800
50     OFF ERROR
60     !
70     ASSIGN @Pipe TO "SINDAT"
80     OPTION BASE 1
90     DIM Volts(100)
100    !
110    !
120    CALL Compute(Volts(*))
130    !
140    !
150    OUTPUT @Pipe;Volts(*)
160    ASSIGN @Pipe TO *
170    END
180    !
190    !
200    SUB Compute(Array(*))
210    !  Compute 100 values of 3 cycles of a sine
220    !  Results go to Array
230      I=1   ! I is the 100 step counter
240    REPEAT
250      X=(I)*360*3/100   ! 3 cycles, 100 points
260      Array(I)=SIN(X)*10
270      I=I+1
280    UNTIL I>100
290    SUBEND
```

Exercise 18

```
10! SAVE "BLD_DATA"
20!
30     OPTION BASE 1
40     DIM A$(20)[20]
50     !
60     !
70     DATA MISISSIPPI,NABRASKA,COLORADO,OREGON,KANSAS,MISSOURI,OHIO
80     DATA OREGON,MISISSIPPI,NORTH DAKOTA,SOUTH DAKOTA,WYOMING,NEVADA
90     DATA MISISSIPPI,NABRASKA,NEBRASKA,MISSISSIPPI,PENNSYLVANIA,VIRGINIA
100    DATA NEW YORK,FLORIDA
110    !
120    !
130       DISP "Preparing Data"
140    FOR I=1 TO 20
150    READ A$(I)
160    NEXT I
170    !
180       DISP "Loading subprogram"
190    LOADSUB ALL FROM "WRITEBDAT"
200       DISP "Calling subprogram"
210    CALL Write_data(A$(*))
220   END
```



```
10! STORE "writebdat"
20 !
30    SUB Write_data(Data$(*))
40 !
50    OPTION BASE 1
60 !
70 !
80 !  This segment attempts to set up the file
90       DISP "Setting up data file"
100   ON ERROR GOTO 120
110   PURGE "BDAT_DATA"
120   CREATE BDAT "BDAT_DATA",20,25
130   OFF ERROR
140!
150!
160!  This segment writes the data to the file
170      DISP "Writing data to file"
180   ASSIGN @Pipe TO "BDAT_DATA"
190   FOR I=1 TO 20
200      OUTPUT @Pipe,I;Data$(I)
210      PRINT I,Data$(I)
220   NEXT I
230   ASSIGN @Pipe TO *
240 !
250   SUBEND
```

Solution 19

```
10! SAVE "RAND_UPDT"
20!
30    OPTION BASE 1
40    DIM A$(20)[20]
50    !
60    !
70       DISP "Reading Data"
80    PRINT "Record";TAB(10);"Item"
90    ASSIGN @Pipe TO "BDAT_DATA"
100   FOR I=1 TO 20
110      ENTER @Pipe,I;A$(I)
120      PRINT I;TAB(10);A$(I)
130   NEXT I
140   !
150   CALL Update(A$(*),@Pipe)
160   END
170   !
171   !
172   !
180 SUB Update(Data$(*),@File)
200   OPTION BASE 1
220!
230!
240!  This segment updates the file.
241   LOOP
250          INPUT "Record number to update? (0 when done)",Num
260   EXIT IF Num=0
270          INPUT "Enter the new item:",Data$(Num)
280!
290!  Write the new data to the file
300          DISP "Writing data to file"
310          OUTPUT @File,Num;Data$(Num)
320          PRINT Num,Data$(Num)
330          INPUT "Next record number to update? (0 when done)",Num
340   END LOOP
350          ASSIGN @File TO *
360 !
370   SUBEND
```

Solution 20

```
10! SAVE "TRAP_END"
20!
30     OPTION BASE 1
40     DIM A$(20)[20]
50     !
60     !
70        DISP "Reading Data"
80     PRINT "Record";TAB(10);"Item"
90     ASSIGN @Pipe TO "BDAT_DATA"
100 ON END @Pipe GOTO Continue   !****************
110        I=1                   !****************
120 LOOP                         !****************
130       ENTER @Pipe,I;A$(I)
140       PRINT I;TAB(10);A$(I)
150        I=I+1                 !****************
160 END LOOP                     !****************
170    !
180 Continue:  CALL Update(A$(*),@Pipe)   !******
190    END
200    !
210    !
220    !
230 SUB Update(Data$(*),@File)
240    OPTION BASE 1
250!
260!  This segment updates the file.
270    LOOP
280         INPUT "Record number to update? (0 when done)",Num
290    EXIT IF Num=0
300         INPUT "Enter the new item:",Data$(Num)
310!
320!  Write the new data to the file
330         DISP "Writing data to file"
340         OUTPUT @File,Num;Data$(Num)
350         PRINT Num,Data$(Num)
360    END LOOP
370         ASSIGN @File TO *
380 !
390    SUBEND
```

Solution 21

```
10 ! SAVE "SPEED"
20   OPTION BASE 1
30 !   This Prog demo's a BDAT file with & w/o
40 !   an EOF at the end of data file "NUM_DAT".
50 !   Also, FORMAT ON/OFF is illustrated.
60 !
70 !   The variable Pass_num indicates whether we
80 !   have set up the disc and computed the array
90 !   previously.  It is in COM so its value is
100!   preserved from run to run.
110 !
120    DIM Array(1200)
130    INTEGER Pass_num
140 !
150    IF Pass_num=0 THEN Pass_num=1
160 !
170 Loop_again:!
180     PRINT "Number ";Pass_num,
190 !
200 !   This loop sets up the data file on disk.
210 !
220 IF Pass_num=1 THEN
230       DISP "Setting up disc, please wait "
240 !
```

```
250      ON ERROR GOTO 270
260      PURGE "NUM_DAT"
270      OFF ERROR
280 !
290     CREATE BDAT "NUM_DAT",1,20000
300 END IF
310 !
320 !
330 !
340 ! This section toggles FORMAT ON/OFF
350 !
360   IF Pass_num<=4 THEN
370      ASSIGN @Pipe TO "NUM_DAT";FORMAT ON
380      PRINT "  FORMAT ON"
390   ELSE
400      ASSIGN @Pipe TO "NUM_DAT";FORMAT OFF
410      PRINT "  FORMAT OFF"
420   END IF
430   CONTROL @Pipe,7;1,1 !Set EOF to byte # 1
440 !
450 !
460 IF Pass_num=1 THEN
470   DISP "Calculating data items"
480     FOR I=1 TO 1200
490        Array(I)=RND*10^(RND*10)
500     NEXT I
510 END IF
520 !
530 !
540  SELECT Pass_num
550   CASE 3,4
560     CONTROL @Pipe,7;1,20000
570     PRINT "Moved EOF to end of file"
580          ! Reg 7&8 of @Pipe puts an EOF mark
590          ! at the 20000th byte of NUM_DAT
600   END SELECT
610 !
620 !
630   DISP "Writing data to disc"
640   T0=TIMEDATE
650       IF Pass_num MOD 2=1 THEN   ! (It's ODD)
660           PRINT "Outputting entire array (1200 elements)"
670           OUTPUT @Pipe,1;Array(*),
680       ELSE
690           PRINT "Outputting 120 elements one at a time. (1200 takes too long
)"
700           FOR I=1 TO 120
710             OUTPUT @Pipe;Array(I),
720           NEXT I
730       END IF
740   !
750       STATUS @Pipe,6;I
760       PRINT "Total bytes on data file =";I
770       ASSIGN @Pipe TO *
780   !
790   !
800   T1=TIMEDATE
810   BEEP 3500,.5
820   DISP
830   PRINT "Disc Transfer Time =";DROUND(T1-T0,4);"sec."
840   BEEP
850   Pass_num=Pass_num+1
860   PRINT
870   IF Pass_num<=6 THEN GOTO Loop_again
880   END
```

Solution 22

```
10 ! SAVE "READ_SIN"
20    ON ERROR GOTO Problem   ! Just in case...
30    OPTION BASE 1
40    DIM Volts(100)
50 !
60 !
70 ! Read from disc file
80    ASSIGN @Pipe TO "SINDAT"
90    ENTER @Pipe;Volts(*)
100   ASSIGN @Pipe TO *
110!
120! Write to CRT
130   ASSIGN @Pipe TO 1
140   OUTPUT @Pipe;Volts(*)
150!
160! Write to Printer
170   ASSIGN @Pipe TO 701
180   OUTPUT @Pipe;Volts(*)
190   STOP
200!
210 Problem:   BEEP
220   PRINT "You probably didn't create file SINDAT."
230   PRINT "Run program WRITE_SIN to build the file."
240   END
```

D4-25

```
10!    SAVE "IMG_EXPLS"
20!
30! This "program" illustrates several methods
40! of using IMAGE with I/O statements.
50!
60!
70   IMAGE 10(S6D.2D)
80   OUTPUT 1 USING 70;1,2,3.4,5,6,7;8;9;10
90 !    Note either commas or semis are OK.
100!
110!
120  PRINT USING Image1;6.08
130 Image1:      IMAGE /,"Volts = ",K,/
140!  Note that the IMAGE statement can be
150!  referred to by line label...anywhere.
160!
170!
180  Image$=" ,6X,2D.2DE,/"
190  OUTPUT 1 USING Image$;1,2,3,4,5
200!  Note that a string variable can be used
210!  to hold the image specifications.
220!  Note also that the data was forced to
230!  conform to the image: it doesn't look
240!  at all like 1,2,3,4, or 5!
250  END
```

```
10!  SAVE "SPECIFIERS"
20  PRINT "*** Digit specifier examples:"
30  PRINT "Number=1234: IMAGE 9Z",
40  PRINT USING "9Z";1234
50  PRINT "Number=1234: IMAGE 9D",
60  PRINT USING "9D";1234
70  PRINT
80  PRINT "*** Radix examples:"
90  PRINT "Number=1234: IMAGE 4Z.4D",
100 PRINT USING "4Z.4D";1234
110 PRINT "Number=1.236: IMAGE 4D.2D",
120 PRINT USING "4D.2D";1.236
130 PRINT "  (notice rounding)"
140 PRINT
150 PRINT "*** Exponent examples:"
160 PRINT "Number=1234: IMAGE 3D.DE",
170 PRINT USING "3D.DE";1234
180 PRINT "Number=1234: IMAGE 3D.DESZ",
190 PRINT USING "3D.DESZ";1234
200 PRINT "Number=1234: IMAGE 4D.DESZ",
210 PRINT USING "4D.DESZ";1234
220 PRINT "Number=1234: IMAGE 2D.DESZZZ",
230 PRINT USING "2D.DESZZZ";1234
240 PRINT "  (notice rounding)"
250 PRINT
260 PRINT "*** Sign examples:"
270 PRINT "Number=1234: IMAGE S2D.DE",
280 PRINT USING "S2D.DE";1234
290 PRINT "Number=1234: IMAGE M2D.DE",
300 PRINT USING "M2D.DE";1234
310 PRINT "Number=-1234: IMAGE M2D.DE",
320 PRINT USING "M2D.DE";-1234
330 PRINT
340 PRINT "*** Binary examples"
350 PRINT "Numbers= 94,126: IMAGE B,B",
360 PRINT USING "B";94,126
370 PRINT "Number= 19887: IMAGE W",
380 PRINT USING "W";19887
390 PRINT "Number= 12 (formfeed): IMAGE B",
400 PRINT USING "B";12
410 !
420 PRINT "*** String examples"
430 PRINT "String= 'text text'"
440 PRINT "IMAGE 3A ",TAB(31),
450 PRINT USING "3A";"text text"
460 PRINT "  (note truncation)"
470 PRINT
480 PRINT "String= 'text text'"
490 PRINT "IMAGE 20A",TAB(31),
500 PRINT USING "20A";"text text"
510 PRINT
520 PRINT "String= 'text','text'"
530 PRINT "IMAGE 4A,7X,4A ",TAB(31),
540 PRINT USING "4A,7X,4A";"text","text"
550 PRINT
560 PRINT "Number= 1.23"
570 PRINT USING "#,6A,B,6A,B,9A,8X";"IMAGE ",34,"Volts=",34,",3X,D.3D"
580 PRINT USING 590;1.23
590 IMAGE "Volts=",3X,D.3D
600 PRINT
610 PRINT "*** Record control examples:"
620 PRINT "SEND EOL: Numbers= 123.4, 5.678"
630 PRINT "IMAGE 4D.2D,2/,4D.2D   ";CHR$(10)
640 PRINT USING "4D.2D,2/,4D.2D";123.4,5.678
```

```
650 PRINT
660 PRINT "SUPPRESS EOL: Number1= 1.234"
670 PRINT "Number2= 5.678"
680 PRINT "Number1 IMAGE #,D.3D,3X"
690 PRINT "Number2 IMAGE D.2D"
700 PRINT
710 PRINT USING "#,D.3D,3X";1.234
720 PRINT USING "D.3D";5.678
730 PRINT
740 PRINT "Form-feed: IMAGE @"
750 PRINT USING "@"
760 END
```

D4-28

```
10!   SAVE "REP_FAC"
20     OPTION BASE 1
30    DIM Array(48),Image$[50]
40    DATA 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20
50    DATA 21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40
60    DATA 41,42,43,44,45,46,47,48
70    FOR I=1 TO 48
80    READ Array(I)
90    NEXT I
100   Image$="24(S2D.4D,10X,S2D.4D,/)"
110   OUTPUT 1 USING Image$;Array(*)
120   END
```

Solution 23

```
10 ! SAVE "SIN_IMAGE"
20     ON ERROR GOTO Problem   ! Just in case...
30     OPTION BASE 1
40     DIM Volts(100)
50 Image1:     IMAGE 20(5(2D.3D,3X),/)
60 Image2:     IMAGE 10(10(2D.3D,2X),/)
70 !
80 !
90 ! Read from disc file
100    ASSIGN @Pipe TO "SINDAT"
110    ENTER @Pipe;Volts(*)
120    ASSIGN @Pipe TO *
130!
140! Write to CRT
150    ASSIGN @Pipe TO 1
160    OUTPUT @Pipe USING Image1;Volts(*)
170!
180! Write to Printer
190    ASSIGN @Pipe TO 701
200    OUTPUT @Pipe USING Image2;Volts(*)
210    STOP
220!
230 Problem:  BEEP
240    PRINT "You probably didn't create file SINDAT."
250    PRINT "Run program WRITE_SIN to build the file."
260    END
```

D4-29

```
10!  SAVE "KBD_OUT"
20     DIM A$[50]
30     OUTPUT 2 USING "#,K";"Edit and add to this text that you 'typed'."
40     ENTER 2;A$
50     PRINT A$
60     END
```

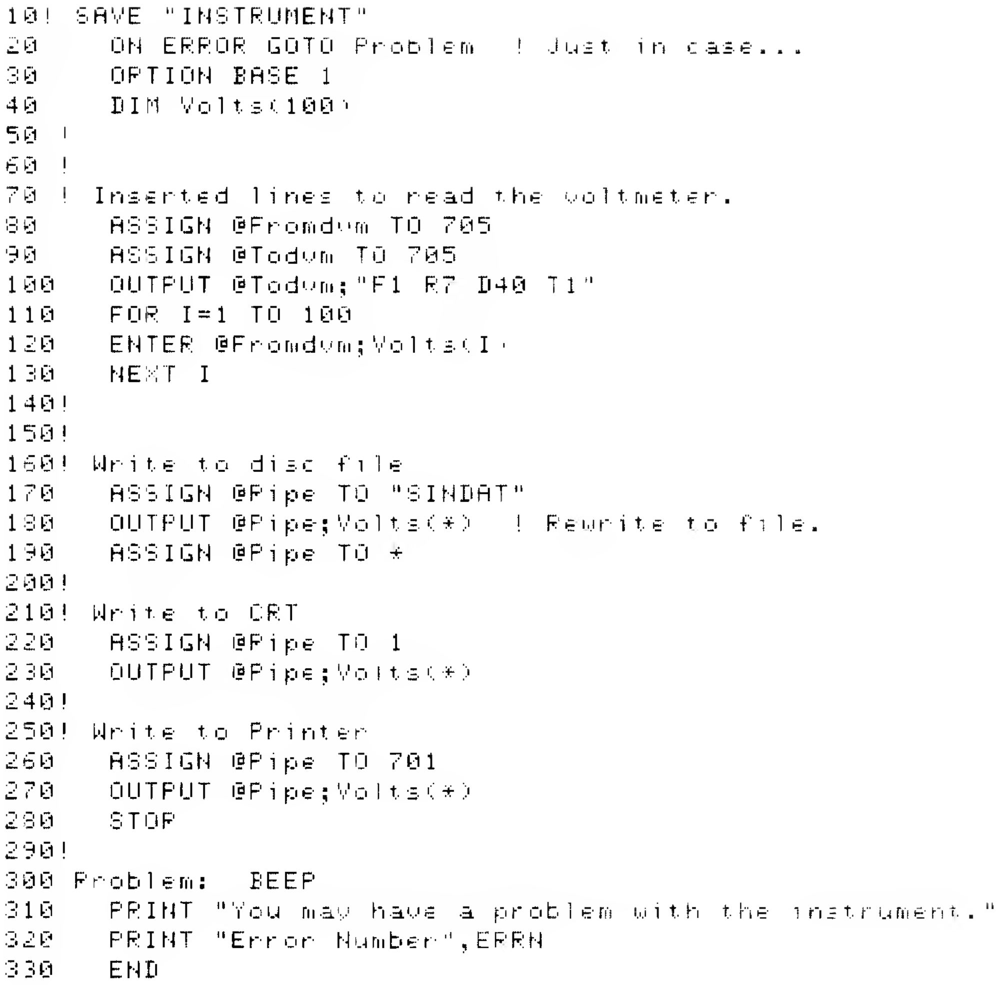
D4-30

```
10! SAVE "READ_CAT"
20     DIM A$[50]
30     OUTPUT 2 USING "#,K";"CAT▒X" !Execute CAT
40     OUTPUT 2 USING "#,K";"▒T" !Push top of form.
50     REPEAT
60     ! Read the display and scroll down one line.
70       PRINT TABXY(1,1);       !Set read position.
80     ENTER 1;A$                !Read the screen.
90       Count=Count+1
100      DISP A$
110      OUTPUT 2 USING "#,K";"▒^" !Scroll down.
120      WAIT .15
130    UNTIL Count=60
140    END
```

Solution 24

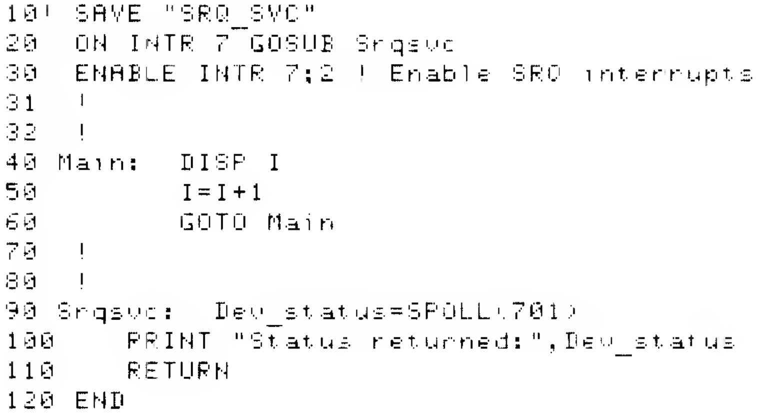
```
10! SAVE "ON_KBD"
20    DIM Key$[20]
30    CONTROL 2,7;2
40    ON ERROR GOTO 60
50    !
60    ON KBD ALL GOSUB Keysvc
70    Key$=" "
80 Main:    I=I+1
90          DISP I,Key$,NUM(Key$[1])
100         GOTO Main
110   !
120 Keysvc:    Key$=KBD$
130            IF Key$="▒▒$" THEN STOP
140            RETURN
150    END
```

Solution 25



```
10! SAVE "INSTRUMENT"
20    ON ERROR GOTO Problem  ! Just in case...
30    OPTION BASE 1
40    DIM Volts(100)
50 !
60 !
70 ! Inserted lines to read the voltmeter.
80    ASSIGN @Fromdvm TO 705
90    ASSIGN @Todvm TO 705
100   OUTPUT @Todvm;"F1 R7 D40 T1"
110   FOR I=1 TO 100
120   ENTER @Fromdvm;Volts(I)
130   NEXT I
140!
150!
160! Write to disc file
170   ASSIGN @Pipe TO "SINDAT"
180   OUTPUT @Pipe;Volts(*)  ! Rewrite to file.
190   ASSIGN @Pipe TO *
200!
210! Write to CRT
220   ASSIGN @Pipe TO 1
230   OUTPUT @Pipe;Volts(*)
240!
250! Write to Printer
260   ASSIGN @Pipe TO 701
270   OUTPUT @Pipe;Volts(*)
280   STOP
290!
300 Problem:  BEEP
310   PRINT "You may have a problem with the instrument."
320   PRINT "Error Number",ERRN
330   END
```

Solution 26



```
10! SAVE "SRQ_SVC"
20  ON INTR 7 GOSUB Srqsvc
30  ENABLE INTR 7;2 ! Enable SRQ interrupts
31   !
32   !
40 Main:   DISP I
50         I=I+1
60         GOTO Main
70   !
80   !
90 Srqsvc:  Dev_status=SPOLL(701)
100    PRINT "Status returned:",Dev_status
110    RETURN
120 END
```

Solution 28

```
10! SAVE "POTPOURRI"
20    ON KEY 1 LABEL "GSB P1",1 GOSUB Pri1
30    ON KEY 2 LABEL "GSB P2",2 GOSUB Pri2
40    ON KEY 3 LABEL "GSB P3",3 GOSUB Pri3
50    ON KEY 19 LABEL "ABORT",15 RECOVER Pri15
60    ON ERROR RECOVER Pri15
70    ON KNOB .1,4 CALL Knobsvc
80    ON INTR 7,15 CALL Srqsvc
90    ENABLE INTR 7;2
100   !
110   !
120 Main:  C=C+1
130   DISP " IN MAIN, COUNTER =";C
140   WAIT .1
150   CALL Nest(1)
160   GOTO Main
170   !
180 Pri15:  !
190         FOR X=1 TO 500
200         DISP "RECOVERED to Main";X
210         NEXT X
220   GOTO Main
230   !
240   !
250 Pri1:   FOR I=1 TO 500
260         DISP "AT PRIORITY 1",I
270         NEXT I
280         RETURN
290         !
300 Pri2:   FOR I=1 TO 500
310         DISP "AT PRIORITY 2",I
320         NEXT I
330         RETURN
340         !
350 Pri3:   FOR I=1 TO 500
360         DISP "AT PRIORITY 3",I
370         NEXT I
380         RETURN
390   END
400   !
410   !
420 SUB Srqsvc
430       FOR X=1 TO 500
440         DISP "IN Subprogram, PRIORITY 15:";X
450       NEXT X
460 SUBEND
470 !
480 !
490 SUB Knobsvc
500       DISABLE
510       FOR X=1 TO 500
520       DISP "IN Knobsvc, interrupts disabled",X
530       NEXT X
540       ENABLE
550 SUBEND
560 !
570 !
580 SUB Nest(Nest)
590       DISP "Nesting level",Nest
600       ALLOCATE Temp(100)
610       Nest=Nest+1
620       WAIT .05
630       CALL Nest(Nest)
640 SUBEND
```

D5-6

```
1 ! SAVE "CIRCLE"
10      DEG
20      GINIT
30      GRAPHICS ON
40      Y=50
50      X=50
60      R=40
70      MOVE X,Y
80      FOR I=0 TO 360
90      DRAW X+R*COS(I),Y+R*SIN(I)
100     NEXT I
110     END
```

D5-7

```
1 ! SAVE "SIN_1"
10      DEG
20      GINIT
30      GRAPHICS ON
60      MOVE 0,50
70      FOR X=0 TO 360
80      DRAW X,SIN(X)
90      NEXT X
100     END
```

D5-13

```
1 ! SAVE "FOUR_SIN"
10      DEG
20      GINIT
30      GRAPHICS ON
40      VIEWPORT 0,60,0,45
50      GOSUB 130
60      VIEWPORT 65,130,0,45
70      GOSUB 130
80      VIEWPORT 0,60,55,100
90      GOSUB 130
100     VIEWPORT 65,130,55,100
110     GOSUB 130
120     STOP
130     WINDOW 0,360,-1.5,1.5
140     FRAME
150     MOVE 0,0
160     FOR X=0 TO 360
170     DRAW X,SIN(X)
180     NEXT X
190     RETURN
200     END
```

D5-15

```
1 ! SAVE "FOUR_SIN1"
10    DEG
20    GINIT
30    GRAPHICS ON
40    VIEWPORT 0,60,0,45
50    GOSUB 130
60    VIEWPORT 65,130,0,45
70    GOSUB 130
80    VIEWPORT 0,60,55,100
90    GOSUB 130
100   VIEWPORT 20,100,20,80
110   GOSUB 130
120   STOP
130   WINDOW 0,360,-1.5,1.5
140   FRAME
150   MOVE 0,0
160   FOR X=0 TO 360
170   DRAW X,SIN(X)
180   NEXT X
190   RETURN
200   END
```

Solution 29

```
1 ! SAVE "EGG"
10    DEG
20    GINIT
30    GRAPHICS ON
31    WINDOW 0,100,0,100
40    Y=50
50    X=50
60    R=40
70    MOVE X+R*COS(I),Y+R*SIN(I)
80    FOR I=0 TO 360
90    DRAW X+R*COS(I),Y+R*SIN(I)
100   NEXT I
110   END
```

D5-20

```
10! SAVE "LINES"
20    GINIT
30    GRAPHICS ON
40    CSIZE 4
50    N=4.5    ! Fudge factor for shrinking frames.
60    !
70    ! Step through 10 line types
80    FOR L_type=10 TO 1 STEP -1
90    !
100   LINE TYPE L_type,10
110   !
120   VIEWPORT L_type*N,133-L_type*N,L_type*N,100-L_type*N
130   FRAME
140   IMOVE 1,0     ! Scoot the label over a bit.
150   LINE TYPE 1 ! Select line type 1 for labels
160   LABEL "LINE TYPE ";L_type
170   NEXT L_type
180   !
190   END
```

Solution 30

```
10! SAVE "SIN_LINE"
20    DEG
30    GINIT
40    GRAPHICS ON
50    !
60    VIEWPORT 0,60,0,45
70    L_type=1
80    Rpt=5
90    GOSUB 290
100   !
110   VIEWPORT 65,130,0,45
120   L_type=3
130   Rpt=8
140   GOSUB 290
150   !
160   VIEWPORT 0,60,55,100
170   L_type=8
180   Rpt=11
190   GOSUB 290
200   !
210   VIEWPORT 65,130,55,100
220   L_type=5
230   Rpt=9
240   GOSUB 290
250   !
260   STOP
270   !
280   !
290   WINDOW 0,360,-1.5,1.5
300   LINE TYPE 1
310   FRAME
320   MOVE 0,0
330   LINE TYPE L_type,Rpt
340   !
350   FOR X=0 TO 360
360   DRAW X,SIN(X)
370   NEXT X
380   RETURN
390   END
```

D5-25

```
10! SAVE "SEMILOG"
20    GINIT
30    GCLEAR
40    GRAPHICS ON
50    ! 10 units X axis, 3 units Y axis
60    WINDOW 0,10,0,3
70    GRID 1,0
80    ! Step up Y axis by LGT units
90    ! You get 3 Y lines every GRID stmt.
100   ! You get 10 X lines every GRID stmt.
110   FOR N=1 TO 9
120   GRID 0,1,0,LGT(N)
130   NEXT N
140   END
```

Solution 31

```
10! SAVE "LOGLOG"
20    GINIT
30    GCLEAR
40    GRAPHICS ON
50    WINDOW 0,4,0,3
60    FOR N=1 TO 9
70    GRID 1,1,LGT(N),LGT(N)
80    NEXT N
90    END
```

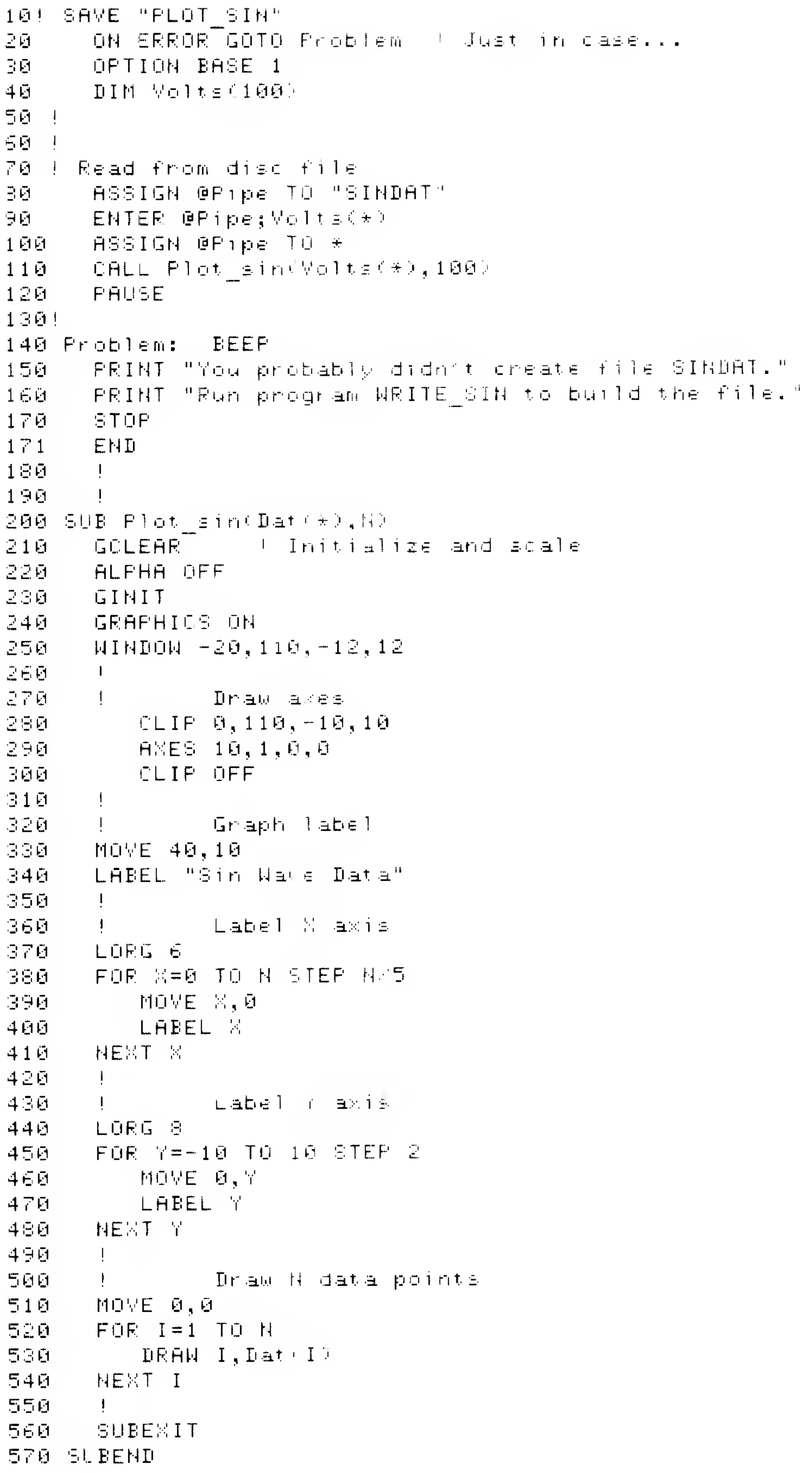
05-27

```
1 ! SAVE "LABELS"
10    GCLEAR
20    GINIT
30    GRAPHICS ON
40    WINDOW 0,5.5,0,5.5
50    AXES 1,1
60    MOVE 2,5
70    LABEL "Graph Title"
80    FOR X=0 TO 5
90    MOVE X,0
100   LABEL X
110   NEXT X
120   FOR Y=0 TO 5
130   MOVE 0,Y
140   LABEL Y
150   NEXT Y
160   ALPHA OFF
170   PAUSE
180   END
```

Solution 32

```
1 ! SAVE "LABELS1"
10    GCLEAR
20    GINIT
30    GRAPHICS ON
40    WINDOW -1,5.5,-1,5.5
50    AXES 1,1
60    MOVE 2,5
70    LABEL "Graph Title"
71    LORG 6
80    FOR X=0 TO 5
90    MOVE X,-.1
100   LABEL X
110   NEXT X
111   LORG 8
120   FOR Y=0 TO 5
130   MOVE 0,Y
140   LABEL Y
150   NEXT Y
160   ALPHA OFF
170   PAUSE
180   END
```

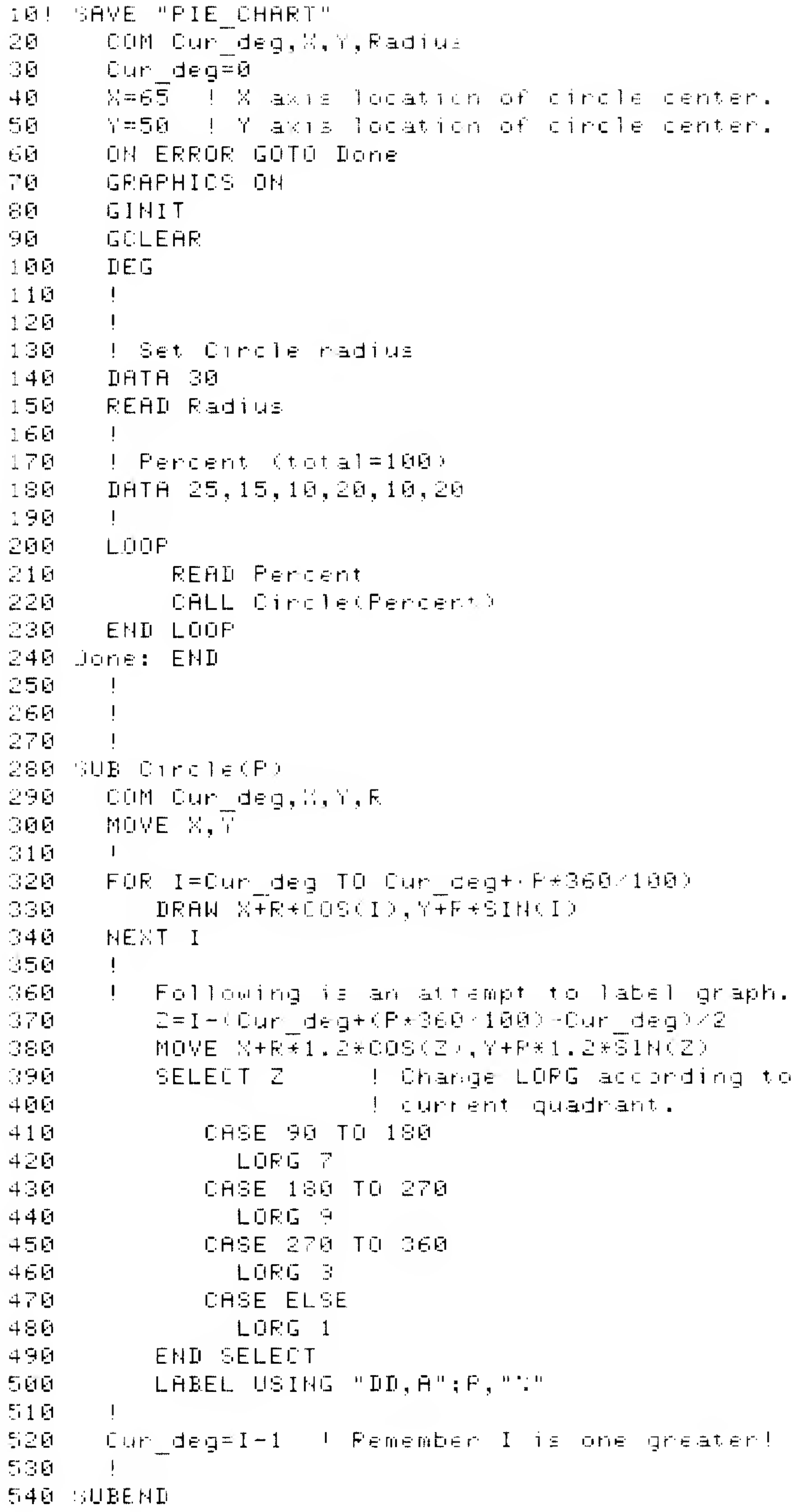
Solution 33



```
10! SAVE "PLOT_SIN"
20    ON ERROR GOTO Problem   ! Just in case...
30    OPTION BASE 1
40    DIM Volts(100)
50 !
60 !
70 ! Read from disc file
80    ASSIGN @Pipe TO "SINDAT"
90    ENTER @Pipe;Volts(*)
100   ASSIGN @Pipe TO *
110   CALL Plot_sin(Volts(*),100)
120   PAUSE
130!
140 Problem:  BEEP
150   PRINT "You probably didn't create file SINDAT."
160   PRINT "Run program WRITE_SIN to build the file."
170   STOP
171   END
180   !
190   !
200 SUB Plot_sin(Dat(*),N)
210   GCLEAR      ! Initialize and scale
220   ALPHA OFF
230   GINIT
240   GRAPHICS ON
250   WINDOW -20,110,-12,12
260   !
270   !       Draw axes
280      CLIP 0,110,-10,10
290      AXES 10,1,0,0
300      CLIP OFF
310   !
320   !       Graph label
330   MOVE 40,10
340   LABEL "Sin Wave Data"
350   !
360   !       Label X axis
370   LORG 6
380   FOR X=0 TO N STEP N/5
390      MOVE X,0
400      LABEL X
410   NEXT X
420   !
430   !       Label Y axis
440   LORG 8
450   FOR Y=-10 TO 10 STEP 2
460      MOVE 0,Y
470      LABEL Y
480   NEXT Y
490   !
500   !       Draw N data points
510   MOVE 0,0
520   FOR I=1 TO N
530      DRAW I,Dat(I)
540   NEXT I
550   !
560   SUBEXIT
570 SUBEND
```

D5-34

```
10! SAVE "ROTATE"
20     ! Set up the plotting space
30     GINIT
40     DEG
50     GRAPHICS ON
60     ALPHA OFF
70     A=SIN(60)*20
80     SHOW 0,50,0,65
90     !
100    MOVE 15,25
110    IMOVE 10,A/2
120    Pen=1
130    !
140    !
150    LOOP    ! Forever
160      Angle=Angle+5
170      PIVOT Angle
180      CALL Triangle(Pen,A)   ! Draw
190    !
200      Pen=-Pen
210      CALL Triangle(Pen,A)   ! Erase
220      Pen=-Pen
230    END LOOP
240    !
250    END
260    !
270    !
280    SUB Triangle(I,A)
290      PEN I
300      X=A/2.5   ! Approximately the center...
310    !
320      IMOVE -10,-X ! Move to angle A
330      IDRAW 20,0   ! Draw to angle B
340      IDRAW -10,A  ! Draw to angle C
350      IDRAW -10,-A ! Draw to angle A
360      IMOVE 10,X   ! Move back to center
370    SUBEND
```



```
10! SAVE "PIE_CHART"
20    COM Cur_deg,X,Y,Radius
30    Cur_deg=0
40    X=65   ! X axis location of circle center.
50    Y=50   ! Y axis location of circle center.
60    ON ERROR GOTO Done
70    GRAPHICS ON
80    GINIT
90    GCLEAR
100   DEG
110   !
120   !
130   ! Set Circle radius
140   DATA 30
150   READ Radius
160   !
170   ! Percent (total=100)
180   DATA 25,15,10,20,10,20
190   !
200   LOOP
210       READ Percent
220       CALL Circle(Percent)
230   END LOOP
240 Done: END
250   !
260   !
270   !
280 SUB Circle(P)
290   COM Cur_deg,X,Y,R
300   MOVE X,Y
310   !
320   FOR I=Cur_deg TO Cur_deg+(P*360/100)
330      DRAW X+R*COS(I),Y+R*SIN(I)
340   NEXT I
350   !
360   !  Following is an attempt to label graph.
370      Z=I-(Cur_deg+(P*360/100)-Cur_deg)/2
380      MOVE X+R*1.2*COS(Z),Y+R*1.2*SIN(Z)
390      SELECT Z        ! Change LORG according to
400                      ! current quadrant.
410         CASE 90 TO 180
420           LORG 7
430         CASE 180 TO 270
440           LORG 9
450         CASE 270 TO 360
460           LORG 3
470         CASE ELSE
480           LORG 1
490      END SELECT
500      LABEL USING "DD,A";P,"%"
510   !
520   Cur_deg=I-1   ! Remember I is one greater!
530   !
540 SUBEND
```

```
10! SAVE "BAR_METER"
20    GINIT
30    GRAPHICS ON
40    VIEWPORT 17,117,25,75
50    FRAME
60    SHOW -1,5,-1,2
70    CLIP 0,4,0,.1
80    AXES .1,0,0,0,10,0,5
90    CLIP OFF
100   !
110   !
120   FOR J=0. TO 4.
130     PEN -1
140     DRAW J-.1,-.4
150     PEN 1
160     LABEL VAL$(J)
170   NEXT J
180   MOVE 1,-.7
190   LABEL "Voltage"
200   !
210   ON KNOB .01 GOSUB Bar
220   Xold=0
230   Xnew=0
240   MOVE 0,.2
250   CLIP ON
260   CLIP 0,4,0,1
270 Main:  GOTO Main
280   !
290   !
300 Bar:    ! Service Knob interrupts and update
310         ! the display.
320         !
330    Xold=Xnew        ! Save the old pointer
340    Xnew=Xnew+KNOBX*.01   ! Make a new one
350    Sign=SGN(Xnew-Xold)
360      PEN Sign
370    IF NOT Sign THEN Sign=1
380    !
390    !
400    ! Beep for overrange and underrange.
410    SELECT Xnew
420       CASE >4
430         BEEP 1500,.2
440         Xnew=4
450       CASE <0
460         BEEP 150,.2
470         Xnew=0
480    END SELECT
490    !
500    !
510    ! Now draw a "bar" of vertical lines from
520    ! the old position to the new one.
530    FOR I=Xold TO Xnew STEP (Sign*.02)
540      MOVE I,.2
550      DRAW I,.6
560    NEXT I
570    !
580    !
590    RETURN
600   !
610   !
620    END
```

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